

THE SEPTEMBER SCIENTIFIC MONTHLY

EDITED BY J. McKEEN CATTELL

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J. McKEEN CATTELL, Editor

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THE SCIENTIFIC MONTHLY

SEPTEMBER, 1937

THE LIFE OF WILHELM CONRAD RÖNTGEN AS REVEALED IN HIS LETTERS

By Dr. OTTO GLASSER

CLEVELAND CLINIC FOUNDATION, CLEVELAND, OHIO

OVER forty years have passed since Wilhelm Conrad Röntgen, professor of physics at the University of Würzburg, (in 1895) saw the effect of a strange and unusual phenomenon while he was performing some experiments in his laboratory. This was the bright fluorescence of some barium platino cyanide crystals near an excited Hittorf tube. He pursued the study of this effect in a most masterly and thorough manner, and discovered it to be due to "a new kind of rays." He called these rays "x-rays." This famous discovery, in addition to his other brilliant researches, placed Röntgen in the ranks of the world's "great men."

In his classic book on "Grosse Mäenner" Wilhelm Ostwald declares that the names of the great in the history of science should have a deeper significance than a mere association with particular data or discoveries which were contributed, for behind each of these discoveries there stands a man, perhaps one who did not tower noticeably above his fellows, who may have had to put forth

a mighty struggle to attain his particular accomplishment. But many modern scientists and research workers evince little interest in the biographies of the great men who have preceded them, and for those who are anxious to know the personal, human side of their scientific forefathers, it often is difficult to obtain reliable information. In some

instances, the man lived so long ago that the events of his personal life have passed into the limbo of a forgotten past, or perhaps he was shy and reticent during his lifetime, leaving little record except of his professional and scientific life. Such was true of Röntgen.

It is difficult to reconstruct a true picture of Röntgen's genius and personality. Since he had little to say about himself, it is not surpris-

ing that others said a great deal for him and of him that was not quite true, and that an amazing web of legend and fable has been woven about him and his discovery. At various times, I have made an attempt to unravel many of these fanciful tales. Although some are highly



RÖNTGEN BUST IN THE MUSEUM
IN LENNEP.



WILHELM CONRAD RÖNTGEN
AT THE TIME OF HIS DISCOVERY OF THE "X-RAYS" (1895).

ingenious and full of romance and imagination, the fabrications in most instances can not be confirmed or even accounted for by a review of the actual facts and occurrences.

When I began my studies on Röntgen, only a few scattered biographical accounts of him had been published, and most of these were written immediately after his death in 1923 to extol his virtues and the importance of his accomplishments. While such eulogies are motivated usually by a sincere and lofty purpose, they often do not present a true, unbiased picture of the man and his character. Hence, however much the great man may be admired, the conscientious biographer must try to expose to light the main facets of his personality, so that he may be seen somewhat as he actually was, rather than as an illusory image conjured up by the eulogist.

There is no more true index of a man's character than his own utterances. His conversations with friends, his publications, his speeches and, best of all, his personal letters show pretty well what manner of man he was. Unfortunately, the writing of letters is fast becoming a lost art; but in Röntgen's day this was not the case, and he, himself, although shy and reticent in his personal contacts, was more articulate and communicative in his letters. Both he and his wife kept in constant touch with their intimate friends and expressed themselves freely on a variety of subjects.

Although the letters do not contain a great deal of information concerning the scientist, Röntgen, they still permit many glimpses of his ideas about research work, as well as education in general, and these indicate the kind of scientist he was. According to Oswald, "The romanticist produces quickly and much; it is his first concern to finish the current problem in order to make way for a new one; the classicist is chiefly concerned with dealing with the current problem thoroughly and exhaustively." Röntgen was a

typical classicist among scientists, and his attitude is well illustrated by a quotation from a lecture which he gave a year before he discovered the x-rays:

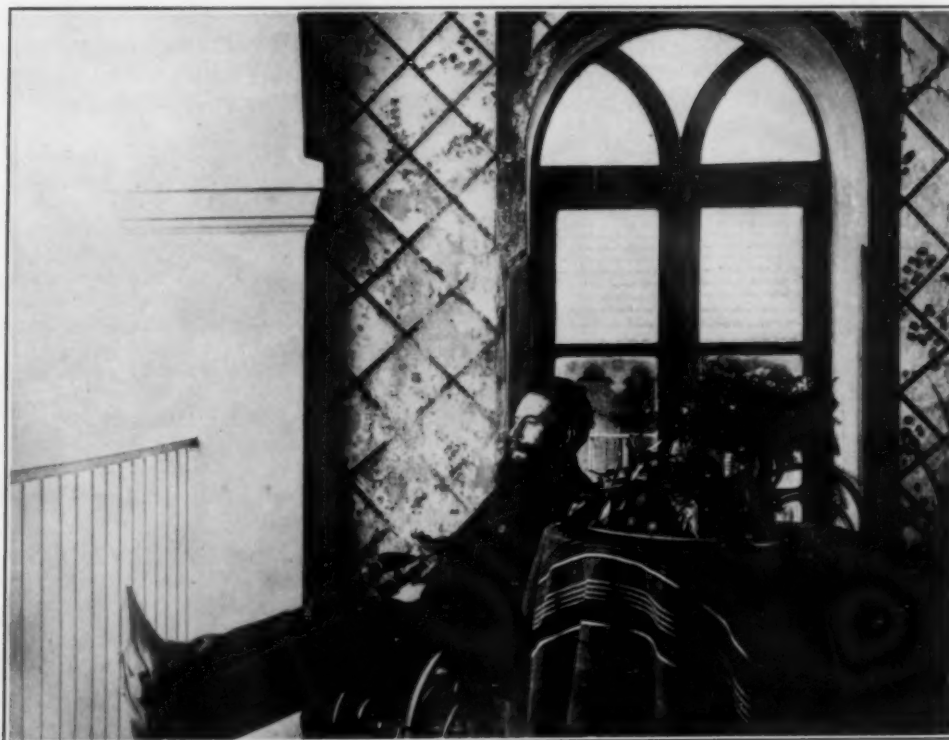
Only gradually has the conviction gained importance that the experiment is the most powerful and the most reliable lever enabling us to extract secrets from nature; and that the experiment must constitute the final judgment as to whether an hypothesis should be retained or discarded. It is almost always possible to compare the results of ratiocination with practical reality, and this gives the experimental research worker the assurance his work requires. If the result does not agree with reality, it must necessarily be wrong, even though the speculations which led to it may have been highly ingenious.

Röntgen again and again called attention to the fact that research work requires great mental effort and a great amount of time, that it necessitates keenness of observation and critical judgment and brings many disappointments. In a speech made before his great discovery, he quoted almost prophetically from a book by the great engineer, Werner von Siemens, the following sentence:

If some phenomenon which has been shrouded in obscurity suddenly emerges into the light of knowledge, if the key to a long sought mechanical combination has been found, if the missing link of a chain of thought is fortuitously supplied, this then gives to the discoverer the exultant feeling that comes with a victory of the mind, which alone can compensate him for all the struggle and effort and which lifts him to a higher plane of existence.

This attitude was expressed again when the enthusiastic students of the old Würzburg University honored Röntgen with a torchlight parade after his discovery. As he addressed the crowd assembled in the Pleicher Ring in front of the Physical Institute, he said:

During the time when honors were showered upon me and unconsciously new impressions erased the older ones, there was always one thought that remained fresh and active in my mind, and that is the memory of the satisfaction which I have felt when my work was finally developed and completed. This is the joy derived from successful effort and from progress.



RÖNTGEN, RESTING IN CADENABBIA, ITALY, A FEW WEEKS AFTER HIS DISCOVERY.

Only a few Röntgen letters have been preserved which refer directly to the discovery of the roentgen rays. Two of these letters, one written by Röntgen to his colleague, L. Zehnder, and the other by Mrs. Röntgen to their cousin, Mrs. Louise Röntgen-Grauel, in Indianapolis, are significant and, on account of their simple language describing the circumstances around the momentous discovery, might be called classics. The letter to Zehnder written shortly after the discovery reads:

Dear Zehnder:

Many thanks for everything which you wrote me. I cannot yet make use of your speculations on the nature of the x-rays, since it does not seem to me to be permissible or propitious, to attempt to explain a phenomenon of unknown nature with a to me not entirely unobjectionable hypothesis. Of what nature the rays are is altogether not clear to me; and whether they are actually longitudinal light rays is to me of second-

dary importance. The facts are the main thing. In this respect my work has received recognition from many quarters. Boltzmann, Warburg, Kohlrausch, (and last but not least) Lord Kelvin, Stokes, Poincaré and others have expressed to me their joy over the discovery and their appreciation. That is worth a great deal to me and I let the envious chatter in peace; I am not concerned about that.

I had not spoken to anyone about my work; to my wife I mentioned merely that I was doing something of which people, when they found out about it, would say: "Röntgen seems to have gone crazy." On the first of January I mailed the reprints and then hell broke loose! The Vienna Press was the first to blow the trumpet of advertising and the others followed. In a few days I was disgusted with the business; I could not recognize my own work in the reports any more. For me photography was the means to the end, but they made it the most important thing. Gradually I became accustomed to the uproar, but the storm cost time; for exactly four weeks I was unable to make a single experiment. Other people could work, only I could not. You have no conception, how upset things were here.

I am enclosing the promised photographs; if you wish to show them in lectures it is all right with me; but I would suggest that you put them under glass and frame. Otherwise, they will be stolen.

How splendidly these words add to the importance of the classical first communication on the x-rays, and how well the following letter of Mrs. Röntgen illustrates the effect on the Röntgen household of the sudden fame following the first reports of the x-rays. The letter was written on March 4, 1896, to Röntgen's cousin, Mrs. Louise Röntgen-Grauel, who lived in Indianapolis and whose daughter kindly gave me the original.

Wilhelm has so much work he doesn't know which way to turn. Yes, dear Louise, it is no small matter to become a famous man, and few people realize how much work and unrest this carries with it. When Wilhelm told me in November that he was working on an interesting problem, we had no idea how it would be received, but as soon as his work was published, our domestic peace was gone. Every day I am

astonished anew at the enormous working capacity of my husband, and that he can keep his thoughts on his work in spite of the thousand and one trivialities with which he is annoyed.

But I am speaking only of the less lovely part of our experiences and have said not a word about our great happiness over the success of his work. Our hearts are full of gratitude that we are permitted to live through such a wonderful experience. How many recognitions my dear has received for his tireless research. It would be alarming if the man who received all this were vain. But you know my honest, modest husband as scarcely any one else does, and you understand that he finds his highest reward in the fact that he was permitted to accomplish something valuable to Science.

In Röntgen's other letters, there is little mention of the discovery. Once many years afterwards, in 1921, when malicious gossip regarding the discovery was finding considerable credence in certain quarters, Röntgen wrote to Mrs. Boveri: "What do you think? Zehnder also has heard the fable that I was not the first to notice the x-ray but that an assistant



RÖNTGEN'S SUMMER COTTAGE IN WEILHEIM, NEAR MUNICH.

or a laboratory *diener* discovered them. What miserable envious souls must have invented this story? I must admit that these lies affect me a great deal more than they should." This statement by an essentially humble man proves his great honesty and dispels any doubt as to the actual circumstances of the discovery.

As Mrs. Röntgen's letter shows, in spite of all the honors heaped upon him, Röntgen remained shy and retiring. The best expression of his modesty perhaps is to be found in his refusal to accept the personal nobility which was associated with the bestowal of the Royal Bavarian Order of the Crown. On June 13, 1896, Röntgen answered a letter from an official who had addressed him as Professor Doctor *von* Röntgen as follows:

In regard to the prefix *von* which you used in connection with my name in your letter of June 4, I should like to say that the paragraph of the rules of the Bavarian Order of the Crown referring to this states: "The decoration of citizens with the Order of Merit of the Bavarian Crown

includes the bestowal of personal nobility, as well as the use of the prefix of nobility, *von*, and can be exercised only after matriculation has been accomplished. Failure to make application for matriculation means forfeiting the rights of nobility." Since to date I have not made such application and since I am not intending to do so, I am not entitled to the use of the prefix *von*. Accept the expression of my sincere esteem. Dr. W. C. RÖNTGEN.

With the same humility he declined to accept many highly flattering invitations to speak before various societies. One of the few he did accept was an invitation to Stockholm to receive the first Nobel Prize for physics. When he returned from that trip he told his colleagues: "The greatest and most satisfying joys the scientist can experience, no matter what problems he may be studying, are those derived from unprejudiced research. Compared to the inner satisfaction over a problem properly solved, any outside recognition becomes meaningless."



RÖNTGEN (CENTER) WITH MEMBERS OF HIS FAMILY (ABOUT 1865).

Naturally, to men of smaller minds and spirits, this idealistic attitude toward his work was difficult to comprehend, and many, motivated by jealousy or lack of knowledge, tried to minimize the importance of his accomplishments. The same intellectual honesty that characterized his attitude toward his work was evident in all his actions, and he had little patience with lesser men in the university who were actuated by selfish, personal motives or with those whose personal prejudices interfered with what Röntgen regarded as the welfare and future progress of science or the institution in which he worked. He had numerous conflicts with his colleagues in Munich over such matters, as shown in a number of his letters to his good friend, Theodor Boveri. Once he wrote: "So

many things could be beautiful and good in Munich if there were not some people who are chiefly convinced of their own importance!"

Röntgen could be gruff, and even rude, when he was aroused by disagreement over such matters, and he was particularly contemptuous of those who were inclined to gild superficial knowledge with brilliant rhetoric. "Physics," he said once, "is a science which must be wooed with honest effort. One can perchance present a subject in such a manner that an audience of laymen may be convinced erroneously that they have understood the lecture. But this means furthering a superficial knowledge which is worse and more dangerous than none at all."

The same thoroughness was carried



RÖNTGEN WITH FAMILY AND FRIENDS IN THE SWISS ALPS NEAR PONTRESINA. FROM LEFT TO RIGHT: MRS. VON HIPPEL, PROFESSOR VON HIPPEL, PROFESSOR BEER, MRS. ZEHNDER, MRS. VON HALLER, RÖNTGEN, PROFESSOR ZEHNDER, BARON VON HALLER, MRS. RÖNTGEN, AND RÖNTGEN'S NIECE, BERTHA (1894).



RÖNTGEN AND MRS. RÖNTGEN

ON THEIR RETURN FROM PONTRESINA, STOPPING AT THE ACHENSEE, SWITZERLAND.

over into his teaching methods, and he tried to inculcate in his students the intellectual honesty and self-reliance that he believed essential to any scientist. He was intolerant of those who did not take to their studies in this spirit, and he always told his assistants: "Do not pamper the student, for it is useless. Let each find his own way out of difficulties."

Many of Röntgen's letters, especially those to Margret Boveri, when she was a young student, illustrate the great respect he had for the study of science, and his ideas and lively interest in various phases of education. When she wrote him that she had begun to study physics, he answered:

The activity of the mind in the study of experimental science, and especially Physics, its not very complicated problems, the probability of reaching a valid solution, and finally the particular method of investigation—the experiment—all this is so very different from that mental activity which is necessary in studying languages or art, that it is very beneficial to learn to know both kinds. Physics is also of great service to

you in another way: all living beings, therefore all human beings, and the latter especially in their early years, are endowed with the ability to make observations and to draw correct conclusions from them. This gift is often withered in youth because of too intensive application to too many educational subjects, and this is a great pity, because it is extremely useful and brings great satisfaction.

He was constantly reiterating the idea that the student himself should contribute something, no matter what, rather than that he should commit and absorb that which others had thought or written on the subject. Once when Margret Boveri wrote him that she had written a composition on Charles the Great, he asked her to send him the manuscript, and then wrote to inquire what source material she had used and under what conditions she had written the essay. After all these questions he said: "I hope that you understand me correctly. I am trying to find out how many of your own ideas you have put into the presentation. Of course I mean the actual

presentation, because the historical part is not so important in this connection." When she gave him this information, he went to the trouble to look up all the references she had used, merely to see how much original effort she had put into that particular assignment.

In writing to her mother regarding the girl's study of music, he stated:

According to my humble opinion, the main emphasis in the musical instruction of a talented pupil should be placed on the teaching of technique and less on implanting the interpretation of the teacher. It certainly may be of interest to learn several interpretations, but the essential interpretation and its reproduction, even though it may be teachable, should be the individual effort of the pupil.

All these illustrations show that Röntgen's ideas on education and his own intellectual habits agree remarkably with those advocated by modern educators and psychologists, for throughout his writings may be found innumerable evidences that he stressed accuracy, intellectual honesty, open-mindedness, suspended judgment, search for true cause and effect and critical judgment, including self-criticism.

The human side of the man, Röntgen, his warm feeling for his friends, his loyalty and interest in them under all circumstances, and his love and devotion to his wife are constantly revealed in his letters. His wife was ill for a number of years, and he cared for her and nursed her devotedly. After her death, he frequently referred to his loneliness and sadness at the loss of her companionship. On her birthday, the year after her death, he wrote to Mrs. Boveri:

Then I reread the letters of condolence which I had received after my wife's death. This was a somewhat sad, yet inspiring occupation. For again I saw how many different kinds of people understood my wife, and how much love and kindness she had earned, and so I ended the day peacefully.

The letters which Röntgen exchanged with his good friends revealed the many

interests that they shared, for they abounded in discussions of scientific subjects, politics, vacations and recreations, nonsense and good humor, and the deepest concern over illnesses and other tragedies. Just before Boveri's death, Röntgen wrote him as follows:

My dear friend:

I found a bottle of sherry in my cellar and it is said that its contents are exactly as old as I am. At any rate, when I bought the bottle in Würzburg, the wine was fifty years old according to the label. I have sent you this contemporary of mine today with the hope that it will contribute its share toward making you feel stronger. If it does that, then the "old hermit" will have done something useful.

As long as the Röntgens were young and well, their letters radiated great good humor and the joy of living. They tell of vacation plans in Switzerland or Italy and contain congratulations for birthdays, Christmas and other holidays and anniversaries. Even when he was old, Röntgen frequently recalled some amusing incident from earlier days, which he would mention in his letters to his friends. Only six months before his death, in recalling some of the experiences of his early married life, he wrote:

In Hohenheim there were rats in our house, and we were on very friendly terms with them. They got their daily food from the garbage in the kitchen sink. Aside from that they didn't disturb us. In our apartment in Strassburg we found bedbugs and cockroaches, but my wife soon exterminated them. We were young and could endure many an inconvenience with some good humor.

One of the chief joys of the Röntgens was their summer cottage in Weilheim and the hunting grounds which surrounded it. Hunting was a favorite pastime with Röntgen, and his letters abound in reference to this sport. His addiction to its joys are ruefully revealed in a letter written to Mrs. Boveri in 1921.

My one sin against the hunting law came about as follows: According to my huntsman, a

deer with very good antlers frequently appeared, browsing in the meadows just where the footpath forms the boundary between Hirschberg's and my own hunting grounds. Often he came over my boundary and then returned. After our experiences during the last few years he probably would have been killed very soon by one of Hirschberg's huntsmen; many of my bucks have disappeared in this manner. As I sat yesterday on my hunting seat about fifty paces from the boundary, just as I was thinking about this, I saw the buck in a more favorable position than I would be likely ever to see him again, and in view of his beautiful antlers, I could not resist shooting. May Saint Hubertus forgive me!

He was also very fond of other outdoor sports. In a letter describing his early student days in Utrecht, he said: "I went horseback riding, skating and in-

dulged in other forms of physical exercise. *Mens sana in corpore sano* is the proverb, if my knowledge of Latin is still accurate." He was an excellent mountain climber, and even on his last trip to Switzerland, not many months before his death, he made long hiking trips through the mountains. He described the joys of this experience in a letter written to his friend, Professor Wölflin of Basel, when he was seventy-six years old.

This is what I wanted to see once more before I die. The roaring mountain stream is for me the symbol of potential power. . . . One of the most beautiful episodes was the delightful trip from Tiefenkaſtel to Lenzerheide; there past

MÜNCHEN, December 6, 1922

Dear Louise:

I have not received an answer to my letter of April 15 of this year but now Christmas-time and the New Year approaches, and that is the time when one likes to get in touch again with those loved ones who are still alive. As usual I can be rather sure to receive some news from you within the near future, provided of course that you are feeling well and are in the mood for writing. I hope that this is the case, but, especially at our age, this is very often uncertain. I frequently ask myself how you are and then I should like to know —

I am feeling rather well. My hearing and sight have decreased considerably and other signs of age have appeared, but I am still rather active and have a good appetite. Memory and ability to work are considerably decreased and loneliness lies heavily upon me. The mistreatment and abuse to which our country is continuously exposed, especially on the part of France and England, is almost unbearable and has led us close to the abyss if not even into it. The future is very dark and the present is without hope and filled with danger. The great middle class is totally impoverished and this impoverishment is increasing rapidly. You probably have no idea of the misery and hardship which exist here. The foreigner who travels in Germany sees only the bright surface, of the fundamentally foul conditions produced by a conscienceless group of profiteers and speculating people and inasmuch as he does not get in touch with other classes he must gain a false impression. Let us hope that in America the spirit of truth and reason will gradually be victorious over the false English and French reports, which have been

propagated widely, and I hope that that will be the case before it is too late for us.

Since I am a government employee, I receive a pension which increases somewhat with the rise of prices of living and am thus relatively secure if I live moderately, but I must continuously practice more and more economy. Just think of it: one pound of bread costs 67 marks; one pound of meat three to four hundred marks; one pound of butter about fourteen hundred marks and a simple suit of clothes about one hundred-fifty to two hundred thousand marks. For one dollar one can get eight thousand marks.

You can imagine that under these circumstances I ordinarily cannot travel in countries that have a high exchange rate, but still I was able this summer to spend three weeks in Switzerland. That was a wonderful time! During this time, I was with people who live under normal conditions. Close to the place where we stayed for some time there is a famous bathing resort, St. Moritz; in the guest list of one of its greatest hotels I found a "Mr. Ernst Roentgen with Governess and Maid, U.S.A." Do you know who this apparently very wealthy namesake could have been? Last summer a daughter of Line Fischer, nee Frowein, from Ede in Holland came to see me. Did you not meet this Line Frowein (my cousin) in Apeldoorn? At my wedding you no doubt met the children of Coö Boddens (my cousin). I still have some correspondence with one of them (Betty). Outside of that I have no connections any more in Holland.

And now, my dear Louise, I wish you a very Merry Christmas, begin the New Year in good health and with courage. Sincerest regards,

your cousin,

W. C. RÖNTGEN



INFLATION MONEY WITH RÖNTGEN'S PICTURE, ISSUED IN WEILHEIM.

and present were united in one brilliant event. . . I still prefer to leave the well worn paths and to hike over stick and stone. I told Ritzmann if ever I should be missed not to look for me on the main road.

Both Röntgen and his wife appreciated beauty in all its forms. In German, we would call them *Lebenskuenstler*, artists of life. They derived much pleasure from music, art, literature, flowers, mountains and woods, and in many letters there are expressions of exuberant enthusiasm for some lovely thing. They both enjoyed music and loved to have their musical friends come and play for them. Once after attending the opera, Röntgen wrote: "How I enjoyed the *Fidelio*. Both overtures were played and Morena sang beautifully. I was quite enthusiastic and carried away by the music. It is wonderful how soothing and refreshing music can be." Another time he said: "Bach's violin concertos are extremely lovely, and I only regret that I did not get acquainted with these beautiful things earlier." During his last year he wrote:

"I enjoy rereading 'Don Quixote,' of which I own a very good edition. I learned again to love the two men, the Don and the Sancho, and enjoyed reading about their cleverness and their interesting characters."

Röntgen was very deeply affected by the fate of Germany in the world war, and his constant concern and interest in the affairs of the Fatherland are revealed in practically every letter written during the last ten years of his life. Although he had spent his early years in Holland and his college years in Switzerland, he had been born in the German Rhineland and his sympathies were all with Germany. At the outset of the war, he embraced the cause, heart and soul, yet he displayed relatively little of the psychosis of hatred so prevalent at the time on both sides, and he felt that many spheres of activity were influenced which should not have been affected at all by the prejudices engendered by the conflict. In December, 1914, he wrote to his friend, Hitzig:

We suffer much from the fact that the feeling in America, especially in the best circles, is strongly anti-German. I see in communications which I receive from learned men there that there exists such a lack of understanding of present events and conditions that one cannot help but ask how people who are ordinarily intelligent and reasonable can have such prejudiced opinions. On the other hand, we also have professors whose behavior is unbecoming.

A few years later he wrote to Boveri:

The other day I received a pamphlet from a Belgian scientist which was somewhat embarrassing to me, especially because it referred to the well known proclamation of the ninety-three intellectuals which I, along with others, foolishly signed without first having read it, at the insistence of the Berliners.

Röntgen followed the events of the war with the most profound interest, and he foresaw with astounding insight many of the bitter consequences which ultimately eventuated. Perhaps his contacts with relatives and friends in neutral countries enabled him to judge the actual situation more accurately. He was not blinded by prejudice or his emotions and was able to see the weakness in certain German institutions and practices. In February, 1915, he wrote:

I do not feel that a quick decisive victory would have been a good thing for us. All of us should feel the seriousness of the war; this might protect us from danger and relieve us of several undesirable faults.

In November, 1918, as the war ended, he remarked:

That we in Germany have left the right path in our social life and that real love for our country has been replaced by a false pride and that we have become too materialistic—all that I told you long before the war, and I have discussed with you what seemed to me the only way to relieve this situation. However, I never would have believed, much less hoped, that we should have to suffer so intensely for our mistakes or that the medicine would come in such bitter doses. The conditions of the Armistice and the stipulations of peace which will probably be made are so depressing that it will be

difficult to keep up enough courage to build up a satisfactory existence under the new conditions.

He displayed a fierce sense of justice, and was extremely bitter about certain events, such as the occupation of the Ruhr valley by French and Belgian troops after the war was over. "All our thoughts are constantly taken up with the infamous invasion into the Rhineland; because that is my homeland it gives me especial cause for alarm and indignation." This was written on January 26, 1923, a few days before his death.

Although he was apprehensive concerning the outcome of the chaos in Germany's political affairs immediately following the war, he preserved his characteristic open-minded attitude in viewing the efforts of the new social democratic government. He commented:

I also must say that all edicts and proclamations of the new Government are very reasonable. It does not waste time in ordering changes in inconsequential matters. In short, I feel that one may well expect from this government the best which can be hoped for. Of course, it is a question whether it can hold its own in the future, at least during the most difficult period of transition or whether ultraradical influences of Bolshevism may gain the upper hand. I believe with others that the latter danger is not imminent at the present time, at least not in Bavaria.

In view of the latest turn of events in Germany, one or two of Röntgen's letters have especial interest and significance. There was a strong wave of anti-Semitic sentiment in the immediate post-war period, upon which he remarked on May 12, 1921, as follows:

The anti-Semitic incidents in Würzburg of which you write are exceedingly regrettable; it is not much better here. For instance, there is hardly an advertisement of rooms for University students which does not contain the statement, "No Jews," and I know of one instance when a woman said to a student who was looking at a room and mentioned his name, which sounded Jewish, "I do not take any Israelites." It is a bad sign of the times that decent persons can thus so rudely be insulted.

On the other hand, years before on December 27, 1906, he complained bitterly in a letter to Zehnder about the "Semitic impudence" of a colleague at the university.

I shall quote one more example of Röntgen's ability to look into the future almost prophetically. On January 26, 1923, he wrote a long letter to Wölfflin which contained a detailed discussion of the political situation in Germany and referred to the following incident:

Martial law was declared in Bavaria yesterday and no public meetings are permitted without government permission. It is said that this regulation is directed against the National Socialists, who under Hitler—perhaps a second Mussolini (?)—caused some disturbance. I

wonder whether it is not too late to lay the ghosts which have already been called forth!

In a short space one can not hope to give a complete picture of the character of a man like Röntgen, but in these few fragments snatched from his personal correspondence, there is perhaps some index of his outstanding characteristics. First among these was his absolute integrity in all things, in his work, his friendships and his attitude toward life, science and art. The deep seriousness of his nature was spiced with a love of fun, a sense of humor, an interest in sports and the outdoors which broadened his outlook and gave him a profound depth of understanding and almost prophetic vision.



RÖNTGEN'S HANDS.

THE KRUGER NATIONAL PARK OF THE TRANSVAAL

By Dr. MARY L. JOBE AKELEY

ADVISER, AKELEY AFRICAN HALL OF THE AMERICAN MUSEUM OF NATURAL HISTORY

ON a recent expedition in South Africa in 1935 and 1936, I visited the Kruger National Park of the Eastern Transvaal, which is generally conceded to be the greatest wild-life sanctuary in the world. Here to-day there is without doubt a greater variety and concentration of wild life than in any other region of equal area on the entire globe. This preserve comprises an overwhelming majority of the African species.

For several years prior to this African journey, I had had the privilege of knowing in London the noted conservationist, Lieutenant-Colonel J. Stevenson-Hamilton, who has been so largely responsible for the preservation of the vanishing fauna of South Africa. Chiefly through his efforts, not only have the remnants of the great game herds been preserved in sanctuary, but they have been so carefully guarded that the animals have increased—some of them to an astonishing degree.

When the clouds of war were gathering above both the English and the Dutch in South Africa in 1898 the Sabi Game Reserve, the forerunner of the Kruger Park, was created. It consisted of an area of 1,500 square miles in extent and included the lands lying between the Crocodile and the Sabi Rivers and immediately west of Portuguese East Africa. Here, at this time, were concentrated the last survivors of the varied and numerous fauna which once roamed over the greater part of South Africa, but which, with the advance of colonization, had been reduced almost to the point of extinction by the white man's gun or the native's spear.

From time out of mind until toward the close of the nineteenth century this

once abundant and highly diversified fauna occupied vast areas between the Cape of Good Hope and the Zambesi. Antelope indigenous to the equatorial regions, as well as other African species peculiarly South African, lived in large and numerous herds in these wide and sparsely settled areas. Spreading across the rolling uplands even to the edge of the Kalahari Desert, great bands of springbuck afforded in their migrations a spectacle as amazing as the periodic journeys of our northern caribou herds. Elephants roamed to and fro across wooded hills where the City of Pretoria now stands. They were found in mighty herds in the lowlands along the Indian Ocean and on the High Veld, and from the Addo Bush to the jungle fastnesses of Portuguese East Africa. Giraffe, buffalo, hippos and black rhinos were plentiful; and the white rhino also was found in abundance from present-day Natal to the Western Transvaal. Among the wooded hills of the southern part of the continent the quagga (*equus quagga*) wandered about in bands so large that no one in that time dreamed that this handsome, vividly marked animal would to-day be exterminated. His cousin, the shy and graceful mountain zebra, now almost extinct as well, inhabited the rock-ribbed hills. Then there were other animals, equally abundant and rarely seen to-day: oribi, blesbuck, bontebuck and white-tailed gnu; and the true nyala, one of the most graceful and beautiful of all the African antelopes. Following stealthily along the trails of these great game herds were the carnivora—lions and leopards, cheetahs and wild dogs.

During the Anglo-Boer War great

changes occurred to the South African fauna. When the conflict was over, the only sanctuary found by these once-enormous herds of game was in the wild mountains and almost impenetrable bush country of the Eastern Transvaal. In 1902, when Colonel Stevenson-Hamilton was placed in charge of the Sabi Game Reserve, he found large areas without any game whatever. Along the Sabi River there were fairly large herds of impalla but almost no bushbuck, duiker or wart-hog. Among the larger antelope, only a very few greater koodoo, waterbuck, sable and roan antelope remained. Burchell's zebra and wildebeest were few indeed. Buffalo and giraffe were almost extinct, numbering in each case only fifteen. But the carnivora still persisted in numbers so great that it was difficult to understand how they could gain a living.

A few years after the establishment of the Sabi Game Reserve, an area 6,000

miles in extent, south of the Olifants (Elephants) River, was added to the original tract. It was extremely wild, well-watered and better-stocked with game than any other region nearby. This tract had originally been surveyed and divided into farms by land companies in Johannesburg. But lovers of wild life now brought great pressure to bear on the situation, to the end that these lands were annexed to the reserve. Fortunately for the wild creatures, hunting, too, had become unpopular throughout the country while the white population was engaged in repairing the ravages of war. A set-back was given to this great plan of conservation when Colonel Stevenson-Hamilton and his staff were called to the colors in the Great War. On their return from the battlefields of France, they found that poaching had become general, and that all the areas near the borders were a mass of traps and snares. Regularly organized native hunting par-



South African Railways and Harbours.

A CLOSE-UP OF AN IMPALLA

ONE OF THE MOST GRACEFUL OF ANTELOPES. THESE CHARMING CREATURES CAN COVER FORTY FEET IN ONE BOUND.



Copyright by Mary L. Jobe Akeley.
THE RARE GREATER KODOO

WHICH SO FAR AS IS KNOWN HAS NOT BEEN PREVIOUSLY PHOTOGRAPHED BY AN AMERICAN.

ties invaded the center of the reserve, where they camped for weeks, killing off the antelope, both large and small, which they converted into *biltong* or smoked meat. It was indeed a serious task which faced Colonel Stevenson-Hamilton. He now determined to control the Transvaal natives, as well as the Portuguese poachers. Finally, in 1922, popular sentiment became thoroughly aroused in favor of the animal sanctuary. The South African railways planned one-day excursions into the southern section of the reserve, in order to allow the passengers to view the game. The general public straightway manifested a tremendous interest in the preservation of wild life; and the national-park idea quickly and firmly took definite shape. Finally in 1924, when the grand-nephew of President Paul Kruger became minister of lands, the Kruger National Park (which as the Sabi Game Reserve President Kruger had first conceived) became a certainty; and in 1926 it was formally established.

Colonel Stevenson-Hamilton has held consistently to two ideals. The first was to reconstruct, in an area comparatively easy to police, the old life of Africa as it

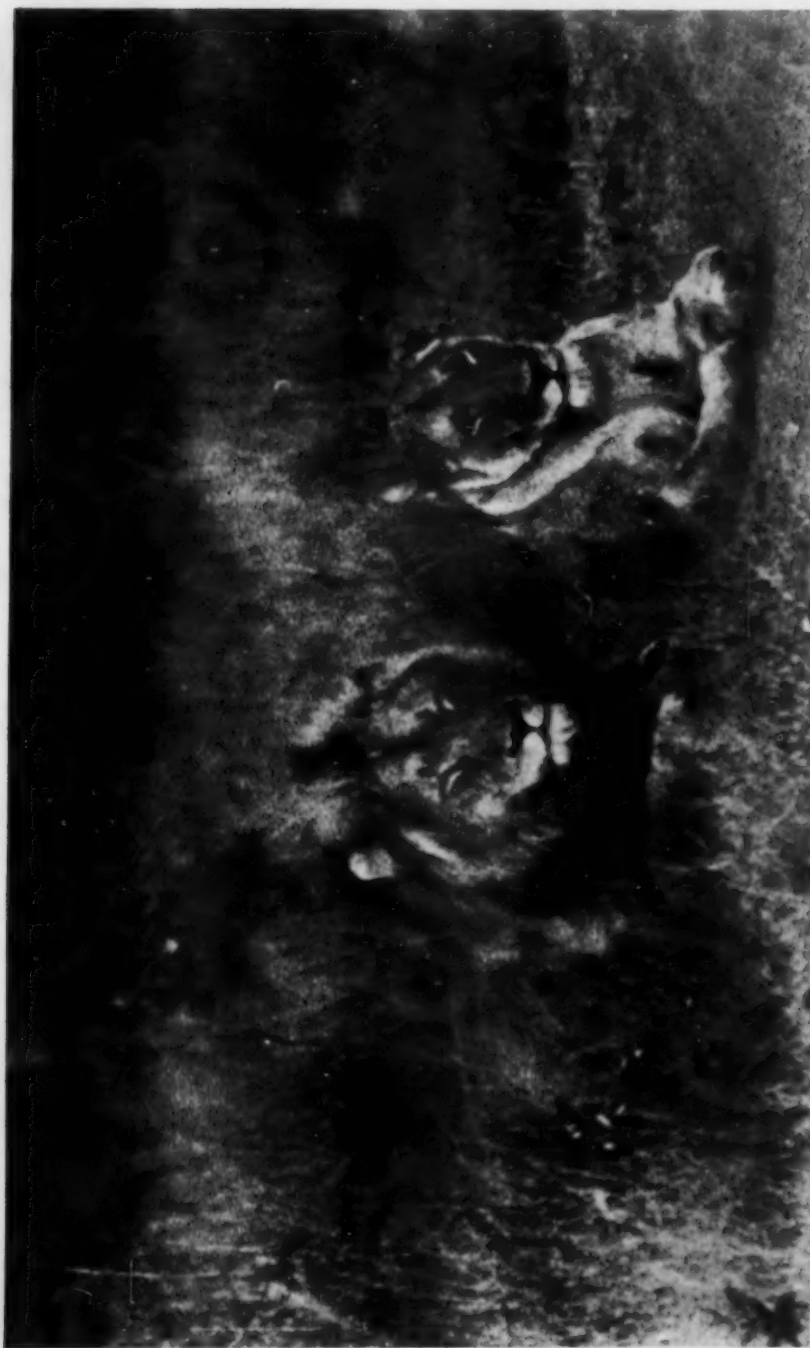


South African Railways and Harbours.
THE AFRICAN ELEPHANT

MANY HAVE TRAVELED IN FROM PORTUGUESE EAST AFRICA AND HAVE FOUND SANCTUARY IN THE KRUGER NATIONAL PARK.

was before the onrush of the white man's civilization. This he has accomplished with amazing rapidity. Starting as he did less than fifteen years ago, he has seen a very scanty and timid fauna increase and become fearless of man, as he travels back and forth at slow speed in a motor car. Where until recently there were only grass lands and thornbush—desolate save for an occasional prowling lion or hyena—now there are large herds of antelope grazing peacefully and without fear of the hunter's gun. One might easily imagine that the impossible had occurred, unless the rapid breeding of these creatures when undisturbed in their natural environment were clearly understood. To-day the Low Veld is literally swarming with the antelope which were so near extinction when Colonel Stevenson-Hamilton took up the fight for their protection. He has undeniably won his battle.

Colonel Stevenson-Hamilton's second ideal was to arouse the minds of the general public to a new way of thinking. For years, they had considered the game only as provender for the pot or as stimulating their enjoyment of a bloodthirsty



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JUNGLE ROYALTY

THE AUTHOR WAS HELD UP ONE EVENING FOR TWO HOURS WHILE OUT IN THE JUNGLE BY THIS PAIR OF MATING LIONS WHICH EFFECTIVELY
BLOCKED HER ONLY ROUTE BACK TO CAMP.

sport. Now he wanted them to grasp the idea that a living creature is infinitely more interesting than a dead carcass, even though the latter has food value. This idea has finally and firmly, even if slowly, prevailed.

It was late winter, the end of August, when I reached this last stronghold of big game. The days were warm and sunny; the nights cool; and the rains had not yet begun. It is undoubtedly the best season in which to visit this wild-life sanctuary. The park area itself, 200 miles long and 50 miles wide, reaches from Rhodesia on the north to Swaziland on the south. It extends beyond the eastern spurs of the Drakensburg Range. Here the great interior plateau known as the High Veld falls off suddenly toward the east into a veritable wilderness of rolling hills, which at a distance have the appearance of an almost-level plain. High ridges and deep ravines are cut here and there by long rivers that make their way through the solitudes of the Lebombo Mountains to the Indian Ocean. This area is between 500 and 1,500 feet in elevation and is thickly clad in virgin bush. Table-topped acacias and dwarfed thorn trees cover the rolling plains, while wild fig trees, palms and vines crowd in a tangle along the water courses. Wild grasses thrive everywhere in the small open spaces, growing so dense and tall along the streams that they obscure equally well a pride of lions or a herd of buffalo.

It is by no means difficult to see the animals in the Kruger National Park. Every part of the reserve may be visited by making one's headquarters in the comfortable rest camps situated only a day's journey apart and connected by well-made roads.

Among the most astonishing sights in the park are the herds of impalla. Here, almost any day, along the lower Sabi, you can see herds of one or two hundred of these graceful tawny creatures. Their rate of increase is so great that, although

many are killed by lions, yet there is no apparent depletion in their ranks. When the visitor approaches, these delightful animals as a rule will remain quietly feeding or else will pause only to gaze at the oncoming motor car. Usually they give ground quite casually. Only when acutely disturbed do they take to sudden flight. Then, in a wild stampede, they will clear the ground in leaps and bounds, vaulting sometimes 20 to 30 feet in the air.

The most glorious animal I saw in the park is the greater koodoo. To me, no creature in the wilds excels a mature koodoo bull in beauty and dignity. As he stands with his exquisitely modeled head held high, his tawny-gray coat brilliantly striped in white and his crown of spiral horns shining in the sun, he is the epitome of grace, strength and grandeur.

A close second to the greater koodoo, if not his equal in distinction, is the sable antelope. He is even more rare and extremely difficult to photograph. The sable bull is strikingly marked. His body is black, shading to brown, and he is almost pure white underneath. His horns are long and formidable, highly arched and sharp as a saber. The female is rufous, and the calves are a somewhat lighter shade. As the sable bull sweeps across the veld, holding his head high, he appears noble, fierce and courageous. His long saber-like horns, the finest weapons carried by an antelope, are so effective that he has nothing to fear from any enemy save the lion, or from one of his own kind when during the mating season the bulls engage in deadly combat. One of the rangers told me that when the sable fights he swings his long curved horns back and forth with startling rapidity, guarding the entire length of his powerful body, one side after the other; and that it would be next to impossible for any enemy to attack him in his position unless similarly equipped. Colonel Stevenson-Hamilton says that he has never found a full-grown sable bull killed by

any of the carnivora except lions; and that only one attack of wild dogs upon a sable was ever witnessed by any of his staff. In captivity, the sable bull usually becomes exceedingly vicious and dangerous; but in the wild state, notwithstanding his courage and power as a fighter, he is never aggressive to man. I was fortunate indeed to photograph, now and then, two or three sable bulls that were ranging apart from the herd; and on one occasion I secured a film of a herd of nine, consisting of bulls, cows and calves less than half grown.

Standing next to the koodoo and sable in size and importance is the water-buck found along all the large rivers. I saw them frequently, in bands of five or six, swimming and wading in the streams or grazing in the grass lands along the shores.

The giraffe herds of the park have now increased remarkably, and in the north-central section they occur in great abun-

dance. Here, ever gentle and appealing in aspect, and only slightly disturbed by the approach of a motor car, they are comparatively easy to photograph. Now and then they posed for me in groups of ten or twelve; and on one occasion I photographed two young giraffe as they cropped daintily at a thorn bush, quite out in the open and not more than 15 feet from my camera.

One morning I had a fine view of seven tsesseby, said to be the swiftest of all the African antelope. Here, they are rarely seen and are considered extremely difficult to photograph. The tsesseby is closely allied to the blesbuck and the bontebuck and is also related to the hartebeest. His nearest relative in equatorial regions is the topi, which has a much darker coat. Topi, like the tsesseby, are found in small bands and are extremely fleet of foot.

The most numerous of the antelope species in the Kruger National Park is



South African Railways and Harbours.

"SEA COWS"

AS THE OLD-TIMERS CALL THE HIPPOPOTAMUSES—ABOUND IN THE CROCODILE AND SABI RIVERS OF THE KRUGER NATIONAL PARK.



South African Railways and Harbours.

WILDEBEEST AND BURCHELL'S ZEBRA
ARE ALWAYS FOUND TOGETHER IN THE KRUGER NATIONAL PARK.

the wildebeest. They are found in small herds in almost every section of the park and are usually accompanied by the Burchell's zebra. These animals, closely akin to the now-extinct *quagga*, are so socially inclined that rarely are they seen in isolated groups. They are extremely shy, constantly on the alert and are said to act as sentinels for the wildebeest herds. Seldom will they face the camera longer than for a few seconds. The moment they sight an intruder, they will trot away for several rods, pause for a little while when quite out of camera range, and then vanish in the bush.

In addition to the antelope previously mentioned, there are bushbuck, reedbuck and duiker. Then there are a few steinbuck, delightful little creatures loving the open grasslands. They are usually seen singly, except in the mating season, when one pair only will travel together. They are timorous little animals and often are seen taking refuge behind a small bush or a tall bunch of grass.

Warthogs are abundant. Some of the males have extremely formidable tusks and are redoubtable antagonists. I heard

of one instance in which a warthog boar attacked and killed a lioness.

A large herd of elephants inhabits the densely forested areas around the Letaba River. Since the creation of the Kruger National Park, many elephants have traveled in from the unprotected areas of Portuguese East Africa and have found sanctuary in this great reserve. Now and then, they come so close to the ranger's stations or to the motor track that visitors to the park are warned by conspicuous signs—"Look out for the Elephant." The fifteen elephants existing in the Sabi Game Reserve in 1902 had increased to a hundred animals in 1922. The herds to-day are larger still, as in the past fifteen years they have been reenforced by other elephants from beyond the Lebombo Hills in Portuguese territory. The buffalo herds, too, have multiplied many times. To-day, several hundred buffalo range in the dense jungles along the lower Sabi River, while smaller herds are often seen near Crocodile Bridge.

Leopards and cheetahs also occur in the reserve. I was fortunate indeed to



South African Railways and Harbours.

LIONS AND LIONESSES

ONE HOT NOONDAY THE AUTHOR SAW A LARGE FAMILY RESTING IN THE SCANTY SHADE OF AN ACACIA TREE.

photograph both of these animals in the light of day.

Besides the animals above mentioned, there are large troops of baboons. These are the chacma baboons, somewhat darker and larger and more sturdily built than the baboons found in East Africa. Often I saw these interesting creatures sitting about close together or feeding in a circle, while the little ones scampered about with one another in the center of the ring. Bands of vervet monkeys gamboled about among the larger trees along the rivers. They are very difficult to photograph, as they are grayish-yellow in color and quite inconspicuous against the gray tree trunks.

Here, too, there is no dearth of bird life. Bustards, francolins and especially guinea fowl are frequently met with. Waterfowl, too, are beginning to come into the sanctuary; knob-billed duck, shell duck and spur-winged geese. Saddle-billed storks, also, have been seen about the waterholes. Guinea fowl,

which present the same appearance as our domestic variety, are so numerous that a flock of thirty or forty feeding in the open is a common sight. They are so unafraid that instead of running quickly to cover as they do in the unprotected zones, they take their own time about moving on. They are of the greatest benefit in destroying harmful insect life.

Perhaps the most interesting of all the animals in the Kruger National Park is the lion. Many visitors travel more than a thousand miles by motor car on their annual holiday with the chief object of seeing the king of beasts in his native haunts. Seldom are they disappointed; for here, where the antelope herds are numerous, the lion no longer has difficulty in solving his problem of existence. In the rest camps, lions frequently may be heard roaring in the night-time or in the very early morning. Shortly after dawn, it is comparatively easy to see a lion on his kill near the road on the lower

Sabi, where they abound. They pay little attention to man in his motor car and seldom take the trouble to seek the seclusion of the bush in order to enjoy their early-morning breakfast. Since it is especially desirable that lions should not associate a motor car with man, it is one of the laws of the park that no one leave a car for the purpose of photography.

I saw many lions under varying conditions, each of which portrayed a different chapter in their habits. One late afternoon I watched a mother teaching her two small cubs to kill. On early mornings I observed lions and lionesses stealthily stalking the game. One early evening I saw six lions patrolling a small pool of water, once a large swamp in which the grass and reeds grew high. Herds of thirsty antelope, zebra and a lone bull giraffe marched up and down on the opposite bank of the drying marsh waiting for a chance to drink. I was told that these lions lay up in the dense vegetation of the swamp during the day and come out only at twilight or at dawn to kill. For more than an hour I watched the thirsty herds approach the pool, then

on getting the scent of the lions stampede back to the safety zone, while the lions kept up their watchful waiting. At last twilight fell upon the scene and I was compelled to return to camp, but knowing full well that when the darkness fell the big cats would kill and feast.

On another occasion I was held up for more than two hours by a pair of mating lions. I had made a wide detour about them through scattered bush, in order to photograph them in the best possible light. Then they had suddenly moved down to the edge of the donga through which I had come, where they effectually blocked my only route back to camp. We tried every possible method to cause them to move from the spot they had chosen. We shouted at them, tooted the motor horn and hurled chunks of wood at them; and finally as darkness overspread the veld we turned on our headlights. But the lions took their own time in moving out of our way. When at last the jungle lovers got up from the floor of the donga, climbed to the opposite bank and then moved a few feet away from the track over which we had come,



South African Railways and Harbours.

THE TRUE OR MOUNTAIN ZEBRA

NOW ALMOST EXTINCT, IS THE SMALLEST OF ALL ZEBRAS. NATURE LOVERS ARE FIGHTING TO PRESERVE THE FEW REMAINING SPECIMENS, WHICH ARE FOUND IN TWO VERY SMALL HERDS IN THE CAPE COLONY.

we were finally able to make our escape. I was then quite certain that I had seen enough of lions for that expedition at least.

The animals of the Kruger National Park are under the constant supervision of the warden, Colonel J. Stevenson-Hamilton, and his corps of able assistants, the rangers of the park. Each white ranger has a staff of native rangers assisting him in the patrol of his territory. These rangers exercise tireless vigilance in their study of wild-life conditions in their domain. They are also equally on the alert for any enemy that might creep in from beyond the borders for the purpose of hunting. In their faithful, watchful patrol of their own districts, they are frequently brought face-to-face with high adventure. Such supervision insures the welfare of the game. The warden and his staff constantly study the conditions of food-and-water supply. They protect the wilderness against fire and assist, as far as it is humanly possible, in the preservation of the balance of nature. This means that no species is allowed to preponderate to the detriment of others. For example, there must be counterpoise maintained between the carnivora and the herbivora. The big cats are not permitted to kill off the antelope to the point of decimating the herds and thus diminish their own normal food supply. On the other hand, if for any reason lions and leopards are reduced unduly by artificial means, then

there is no salutary deterrent to the survival of the unfit. It has been proved beyond contradiction that it is most unfortunate biologically for any herd or family to harbor the decrepit and diseased. There can be no compassion for the aged in jungle law. One of the most serious tasks, therefore, of the warden and his staff is to keep these species strong and healthy, with power to increase normally.

As a result of my intimate study of the wild life of the Kruger National Park, I became not only completely fascinated by the natural beauty of a new land, but even more by this rare opportunity to study at close range the great game herds living under conditions comparable to those before the coming of the white man. Throughout my entire expedition I received invaluable help and great courtesy. To the Prime Minister, General Hertzog, to General Smuts, to the officials of the South African Railway, to Colonel J. Stevenson-Hamilton, to the National Parks Board and to my many new-found friends in South Africa I owe an overwhelming debt of gratitude for their unfailing kindness, their hospitality and for their assistance so graciously and freely offered. From the Hon. Ralph W. Close, South African Minister to Washington, and to the Hon. Charles Te Water, South African High Commissioner in London, I received invaluable help in planning my expedition and to them also I shall ever be deeply grateful.

EARLY EVIDENCES OF INDIVIDUALITY IN THE HUMAN INFANT

By Professor ARNOLD GESELL, Director
(With the assistance of Louise Bates Ames, Ph.D.)

YALE CLINIC OF CHILD DEVELOPMENT, SCHOOL OF MEDICINE, YALE UNIVERSITY

THERE is a popular impression that all babies are much alike, especially young babies. This impression has received some scientific support from those psychologists who hold that the behavior of infants is chiefly patterned through conditioning processes and through specific learning. On the basis of the conditioning theory of development, individual differences at birth are slight and increase with age.

Without pressing unduly the old issue of nature *versus* nurture, we may profitably investigate the question whether individual differences do or do not declare themselves early in life. At the Yale Clinic of Child Development we have gathered data on the problem by periodic behavior surveys of normal infants, by clinical studies of defective and atypical infants, by comparative studies of infant twins, by biographic records of the feeding behavior of infants and by naturalistic cinema records of infants in the situations of everyday life.

The present report is based upon an analysis of the cinema records of five normal infants from homes with high average living conditions (Girl A, Girl B, Boy A, Boy B, Boy D, as delineated in "An Atlas of Infant Behavior").¹ These children were photographed under home-like conditions at lunar months throughout most of the first year. Extensive cinema records embraced the major

¹ Gesell *et al.*: "An Atlas of Infant Behavior: A systematic delineation of the forms and early growth of human behavior patterns." Illustrated by 3,200 action photographs, in two volumes. New Haven: Yale University Press, 1934. Pp. 922.

events of the infant's day, namely sleep, waking, bath, dressing and undressing, feeding, play and social behavior at advancing age levels. Briefer cinema records and psychological observations of the same children were made at the age of five years.

A trained and unbiased observer, Mrs. Louise B. Ames, who had never seen the infants and who knew nothing about them, undertook a detailed analysis of the cinema records covering the first year of life. She made a summary of the behavior of each infant, at each month; and in each situation. On the basis of *the objective evidence of the films alone*, she made an estimate of fifteen behavior traits and arranged the children in rank order for each trait. After this appraisal had been recorded, she made a direct study of these same children, now five years old, at their homes and at the Clinic. The behavior data at five years included an intelligence examination, performance tests and numerous observations of the social reactions of the children to strangers, to the photographic situation and to a tea party in which they participated. The observer made continuous stenographic notes.

After this follow-up study, the observer made a new appraisal of the original fifteen behavior traits. Care was taken to make this an independent appraisal, uninfluenced by the previous ratings which had long ago been set aside.

With these two sets of appraisals it was possible to make a comparative study

of the traits of behavior individuality at one year and at five years of age. This comparison became an experiment in prediction, because we were able to ask with respect to each trait, "Is its strength in the first year of life predictive of a similar strength in the fifth year, when the five children are compared?"

The fifteen traits which were sufficiently objective to yield to clinical appraisal were as follows:

1. *Energy output* (general amount and intensity of activity).
2. *Motor demeanor* (postural bearing, general muscular control and poise, motor coordination and facility of motor adjustment).
3. *Self-dependence* (general self-reliance and self-sufficiency without appeal to the assistance of others).
4. *Social responsiveness* (positive reactivity

to persons and to the attitudes of adults and of other children).

5. *Family attachment* (closeness of affection; degree of identification with the family group).

6. *Communicativeness* (expressive reference to others by means of gesture and vocalization).

7. *Adaptivity* (general capacity to adjust to new situations).

8. *Exploitation of environment* (utilization and elaboration of environment and circumstances in order to gain new experience).

9. "*Humor*" *sense* (sensitiveness and playful reactivity to surprise, novelty and incongruity in social situations).

10. *Emotional maladjustment* (balance and stability of emotional response in provocative situations).

11. *Emotional expressiveness* (liveliness and subtlety of expressive behavior in emotional situations).

12. *Reaction to success* (expression of satisfaction in successful endeavor).

13. *Reaction to restriction* (expressiveness of

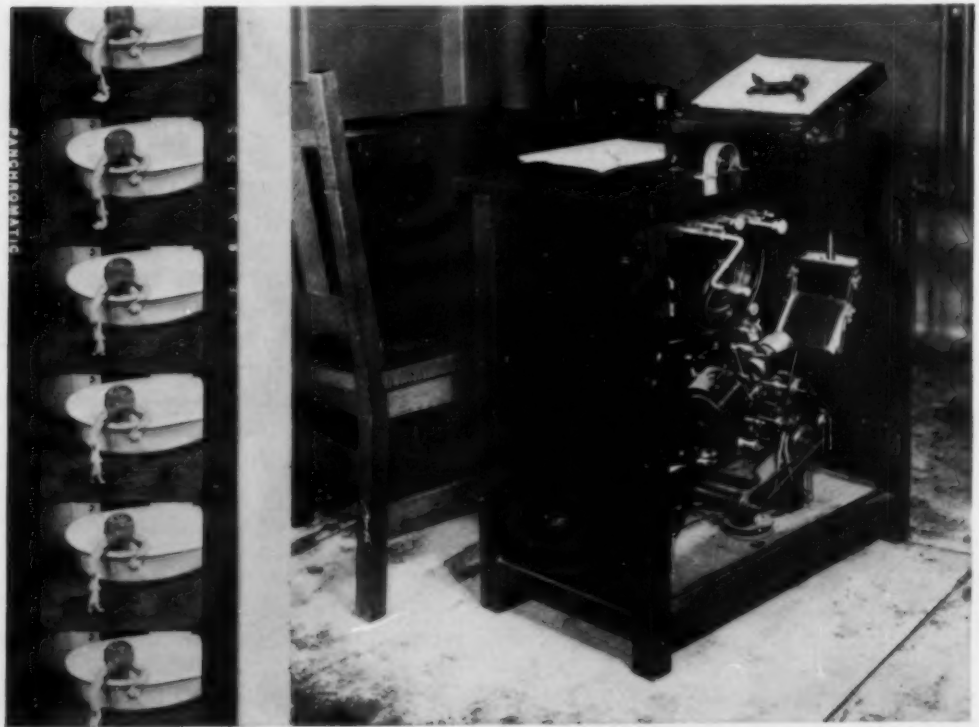


FIG. 1. THIS PRINT WAS MADE DIRECTLY FROM THE CINEMA RECORDS WHICH FURNISHED THE BASIC DATA FOR THE PRESENT STUDY. THE RECORDS DEPICTED THE EVERYDAY LIFE OF THE INFANT. THE FILMS WERE ANALYZED WITH THE AID OF A SPECIALLY DESIGNED PROJECTION DESK.

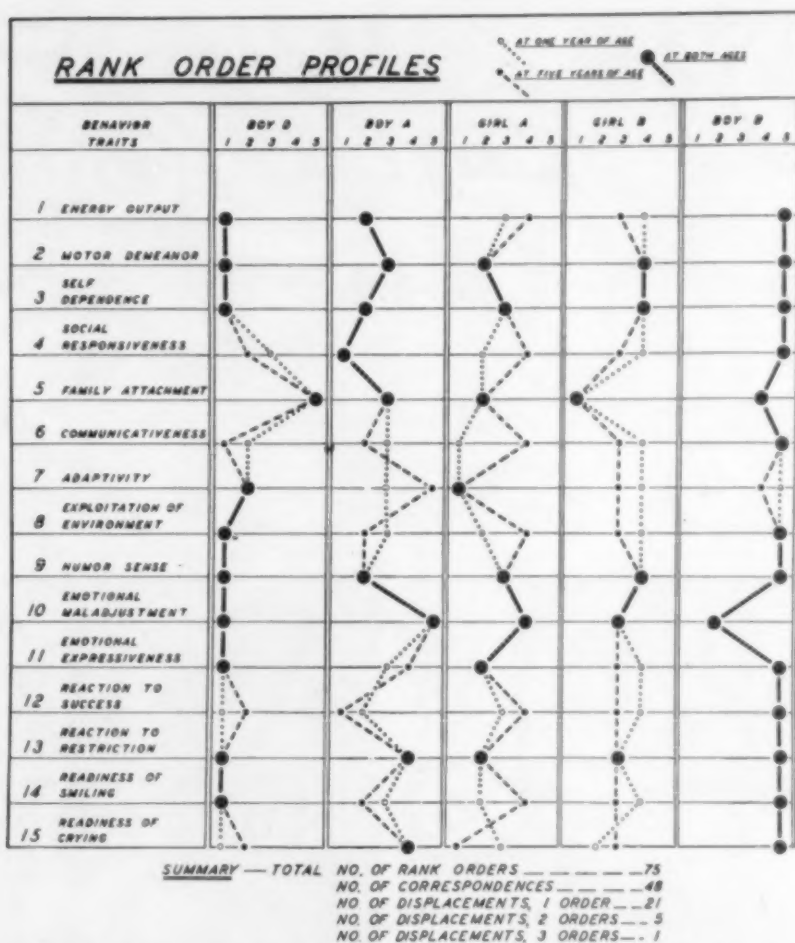


FIG. 2. THIS GRAPH PICTURES THE PREDICTIVENESS OF INDIVIDUALITY TRAITS AS APPRAISED IN INFANCY AND AT THE AGE OF FIVE YEARS. FIFTEEN BEHAVIOR TRAITS LISTED IN THE LEFT COLUMN ARE RATED FOR FIVE CHILDREN IN THE ADJOINING COLUMNS.

behavior in reaction to failure, discomfort, disappointment, frustration).

14. *Readiness of smiling* (facility and frequency of smiling).

15. *Readiness of crying* (promptness and facility of frowning and tears).

In spite of the fact that these categories to some extent overlap, it was found that they yielded to separate judgments based upon objective signs. Errors of judgment tended to remain uniform because they were made by a single observer. In every instance it was possible to assign with certitude the ex-

tremes of the rank order for the fifteen traits and for the group of five children. Intervening rank orders were assigned by bringing the available data into systematic comparison.

The method of cinemanalysis favored a disinterested and objective approach to the basic data. By means of a movieola and a projection desk (see Fig. 1), it was possible to subject the extensive records of infant behavior to thoroughgoing scrutiny. Significant episodes were repeatedly viewed by slowing of motion or by frame-by-frame inspection. In the

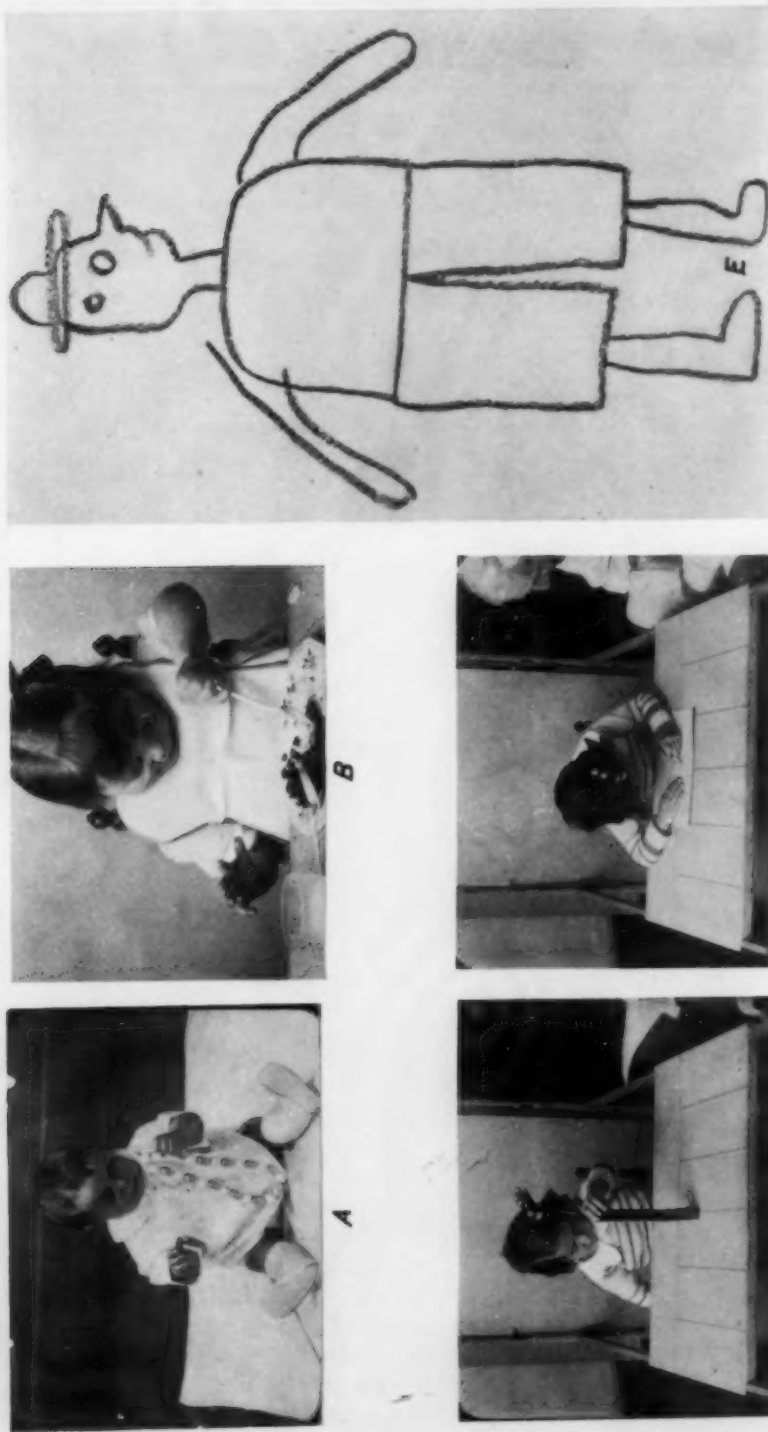


FIG. 3. A DEEP-SEATED MOTOR TRAIT OF INDIVIDUALITY.

THIS CHILD SHOWED PRONOUNCED LEFT-HANDEDNESS: (a) IN MANIPULATION (AGE 36 WEEKS); (b) IN SPOON FEEDING (AGE 80 WEEKS); (c) IN BLOCK BUILDING (AGE 260 WEEKS OR 5 YEARS); (d) IN DRAWING (ALSO AGE 5 YEARS). SHE DRAWS A LEFT-HANDED TYPE OF MAN PICTURED IN e.

field of locomotion the time values of the movements of members of the body were determined and computed for comparative purposes.

Cinemanalysis constitutes a unique method of observation, because it permits at will recurrent observation of events which in nature happen only once. The divisibility of the cinema records also permits a flexible manipulation of the data so that the recorded events can be brought into varied forms of comparison altogether impossible in actual life.

The method of cinemanalysis therefore proved to be admirably adapted to an impersonal treatment of personality data. It should again be recalled that in the present study the cinemanalysis was made by an investigator who had had no first-hand personal contact with the children whatsoever. On the basis of detailed and critically repeated observations an array of predictions was formulated. The behavior survey at five years was made with sufficient thoroughness to bring any serious errors of prediction to light.

The accompanying graph (Fig. 2) summarizes by profiles the rank orders for each of the fifteen behavior traits as assigned at one year and at five years. The heavy lines and large discs in these profiles indicate the items in which there was complete correspondence in the estimates made at the two ages. Dotted and broken lines indicate those instances in which there was a discrepancy between the appraisals at one year and at five years, respectively. Out of 75 judgments, 48 coincided; 21 showed a displacement to the extent of one rank order; 5, a displacement of two orders; 1, a displacement of three orders. The tendency was toward under-prediction. When the rank orders for each of the children are summated into grand totals, the correspondence in the net appraisal ratings at one year and at five years proves to be close: Boy D, 23, 23; Boy A,

43, 42; Girl A, 35, 45; Girl B, 53, 45; and Boy B, 71, 70.

Granting inevitable limitations in the application of the method, these results indicate a high degree of latent predictability in behavior traits manifested in the first year of life. Furthermore, the results do not suggest that fundamental individual differences increase markedly with age. The differences may become more conspicuous without undergoing a true increase.

During the treatment of the data we posed to ourselves a more difficult question, namely: *Are persisting traits of behavior individuality observable in the first sixteen weeks of life?* For three of the subjects, Boy D, Girl A and Boy A, we had ample cinema records for testing such early predictability. When all the estimates were reviewed, it was found that the following traits were definitely noted and correctly appraised (in terms of prediction) prior to sixteen weeks, in all three children: Energy output, Motor demeanor, Self-dependence, Emotional expressiveness, Readiness of smiling. For two of the children the following traits also were recognized prior to sixteen weeks: Social responsiveness, Communicativeness, Adaptivity.

Every infant seems to have what may be called a motor habitude or characteristicness which expresses itself in postural demeanor and modes of movement. This characteristicness is difficult of description because it is the compound result of numerous factors, including skeletal frame, disposition of musculature, speed, synergy, smoothness and precision of action. Some of these factors yield to quantitative study.

One of the most accessible of these is laterality, and even this presented wide variation among the five individuals. By laterality we mean right or left predilection or predominance in motor adjustment. One of our infants (Girl A) showed unmistakable left-handedness as

early as twenty-eight weeks. She has remained definitely left-handed for five years (see Fig. 3). She always will be essentially left-handed. Boy A showed a less marked tendency to left-handedness. Boy D has been emphatically right-handed.

Foot dominance was determined by a careful study of the preferred foot used in prone progression. Boy D showed right foot dominance at thirty-six weeks; Boy A, left foot dominance at forty weeks; Girl B and Boy B, left foot dominance at forty-eight weeks. This dominance is a well-established trait, but we do not know how late in life it persists.

In general bodily control and also in manual dexterity, the four children for whom quantitative data were secured readily fell into the following rank order: 1, Boy D; 2, Boy A; 3, Girl B; and 4, Boy B. Several hundred feet of cinema records were available for measuring the *prehension time* of these children in controlled normative situations. The interval consumed between the zero moment of reaching to the moment of grasp of the test object was computed by counting cinema frames. Each frame has a time value of .05 second. The *prehension time* (that is, the reach-grasp

time) increased with the rank order as follows: Boy D (rank order one), 40 seconds; Boy A (rank order two), 47 seconds; Girl B (rank order three), 50 seconds; and Boy B (rank order four), 60 seconds.

In these time values we apparently have a rather basic trait of motor individuality, for this rank order held up with consistency when the patterns of prone progression were measured in detail. For these measurements over a thousand feet of film depicting creeping behavior were available.

Creeping speed, like prehension time, was measured by counting frames, in this instance the number of frames which recorded a forward movement of a hand or of a leg. A *creep advance* represents a single cycle of progression accomplished by a single forward placement of each of the four members. The total time required for one creep advance was determined for each of the subjects in turn. The time values ranged from .7 to 1.6 seconds for such a single creep advance. Once more the resulting rank order was identical with that just given in the preceding paragraph (see Table I).

Normally the ontogenesis of prone progression follows a sequence of 14 dis-

TABLE I

Motor Traits	Boy D	Boy A	Girl B	Boy B	Girl A
General control, rank order	1	2	3	4	
Manual dexterity, rank order	1	2	3	4	
Prehension time, rank order	1	2	3	4	
Actual time . . . . .	.40 sec.	.47 sec.	.50 sec.	.60 sec.	
Progression:					
Creeping speed, rank order	1	2	3	4	
A creep advance (Stage 11) . . . .	.70 sec.	.85 sec.	1.10 sec.	1.60 sec.	
Near step advance (Stage 12) . . . .	.85 sec.	.85 sec.	1.05 sec.	2.00 sec.	
One step advance (Stage 13) . . . .	.90 sec.	1.00 sec.	1.60 sec.	2.15 sec.	
Alternation pause, rank order					
Simple creep (Stage 11) . . . . .	.65 sec.	.95 sec.	1.65 sec.	1.65 sec.	
Near step (Stage 12) . . . . .	.035 sec.	.04 sec.	.045 sec.	.26 sec.	
One step (Stage 13) . . . . .	.05 sec.	.05 sec.	.20 sec.	.38 sec.	
Age of attaining near step stage	36 wks.	40 wks.	48 wks.	48 wks.	
Summated rank of ages of attaining each of 14 stages	38	43	70	78	
Laterality					
Age of foot dominance	36 wks.	40 wks.	48 wks.	48 wks.	
Dominant foot	Right	Left	Left	Left	
Dominant hand	Right++	L-R (28 wks.)	Right	Right	Left++ (28 wks.)

tinguishable stages. Several of these stages were comparatively studied in our infant subjects. The simple creep advance just described represents the eleventh stage of progression and is generally characteristic of the age of 40 weeks. The *near-step advance* (stage 12, characteristic of 42 weeks) represents the next stage of progression. At this stage, the infant straightens the foot at the ankle and brings it toward a plantigrade posture without actually stepping. This new maneuver consumes additional time. The time values for this behavior pattern were determined, and again the children remained in the rank order already ascribed.

At the *one-step advance* stage (stage 13: 45 weeks), the infant definitely plants the sole of his foot on the locomotion surface. This additional complication requires still more time. In this instance the time values ranged from .9 to 2.15 seconds for the four children, but again the characteristic motor rank order remained undisturbed.

Prone progression is accomplished by alternation of forward thrusts of one arm and the contralateral leg. Between these diagonal thrusts there is a palpable pause which can scarcely be observed by the naked eye, but which can be ascertained and measured by cinemanalysis. This pause diminishes in time for the three types or stages of creeping just mentioned. It however remains at any given stage highly characteristic of the individual, and accordingly the rank order for the alternation pauses remains constant for the four children.

Another individual difference asserted itself with respect to the age at which the various stages of prone locomotion were attained. For example, the ages when the near-step stage was attained were as follows: Boy D, 36 weeks; Boy A, 40 weeks; Girl B, 48 weeks; Boy B, 48 weeks. When the nascent ages for the entire sequence of fourteen stages in

the ontogenesis of progression are expressed in terms of summated rank for each of the four children we get a significant series of values: Boy D, 38; Boy A, 43; Girl B, 70; Boy B, 78. Again the rank order remains true to the characteristic order established by the measurement of specific motor traits.

The accompanying table summarizes these measurements based upon frame by frame cinemanalysis.

In general the most accurate predictions were made for Boy D and for Boy B. These two boys presented contrastive behavior traits, which we may now summarize, if the reader will kindly understand that we do not suggest that one set of traits is necessarily superior to the other set. Each boy, like each of us, is in his psychological make-up a mixture of assets and some liabilities.

As early as the ages of 8 and 12 weeks the highly dynamic personality of Boy D made a strong impression even when observed only through the medium of the cinema. After a full year of recorded behavior had been subjected to such inspection the following adjectives were used to characterize his individuality: quick, active, happy, friendly, well-adjusted, vigorous, forceful, alert, inquisitive. Although he was definitely extrovertive he showed at the early age of 24 weeks a surprising discriminativeness in reading the facial expressions of his mother. By the age of 28 weeks he had developed a moderate temper technique for influencing domestic situations which did not altogether please him. He was able to shift quickly in his emotional response from smiling to crying and from crying to smiling to achieve a desired end. At the age of five years, likewise, his emotional reactions are labile and versatile. He is facile in changing his emotional responses. He is highly perceptive of emotional expressions in others and, correspondingly, highly adap-



FIG. 4. TWO OF THE SUBJECTS WHOSE INDIVIDUALITY WAS STUDIED IN INFANCY AND AT FIVE YEARS OF AGE.

tive in social situations. With this emotional alertness he shows a relatively vigorous detachment from his mother as well as affection for her. He is not given to persisting moods. We do not get the impression that his emotional characteristics have been primarily determined by his life experiences. The underlying nature of his "emotivity" at 12 weeks, at 52 weeks and at 260 weeks seems rather constant. With altered outward configurations a certain characteristicness in emotional reactions is quite likely to persist into his later life.

Boy B presents a different constella-

tion of characteristics. Although by no means emotionally shallow, he is by comparison less vivid, less expressive, more self-contained than Boy D. He is a sturdy, deliberate, moderately sociable, friendly child whose characteristics were evident at one year as well as at five years.

Boy B still shows motor ineptnesses and inhibitions comparable to those which he displayed in infancy. Boy D, on the other hand, has given consistent evidence of superior motor coordination from an early age in postural control, locomotion and manual dexterity. At

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twenty weeks he manipulated a string of wooden beads with precocious discriminativeness; at forty-four, he actuated a hinged rattle with a clever screwdriver movement of the wrists; at one year he pulled out an electric plug in an adaptive manner. At two years he repeatedly inserted and reinserted electric plugs, adjusted bridge lamps, latched and unlatched doors and operated an egg beater. The drive and deftness of his ceaseless manipulation strongly suggest in this instance mechanical insight and aptitude.

We have devoted a paragraph to motor traits because they best lend themselves to objective statement. If other traits of individuality become equally amenable to measurement and appraisal, applied psychology will be increasingly concerned with the detection of individual differences in the first year of life. With the aid of the cinema our exploratory study has demonstrated a significant degree of internal consistency in the behavior features of the same children at one and at five years of age. This consistency seems to rest upon biological characteristicness; a characteristicness which as yet can not be quanti-

tatively formulated in a satisfactory manner but which is incontrovertible.

Our findings must not be over-generalized, but they strongly indicate that certain fundamental traits of individuality, whatever their origin, exist early, persist late and assert themselves under varying environmental conditions. This does not mean that physical and cultural environments have no influence upon the growing organism. It is suggested, however, that this influence may be properly envisaged as operating upon and subject to basic constitutional characters. The extrinsic environment impresses circumstantial and topical configurations, but a certain *naturel* is given, and it is for this reason that we discover such early evidences of individuality in the human infant.

Since we must tread warily in this field of discourse, we shall conclude with a vague but pregnant passage from Shakespeare:

A man may prophesy with a near aim of the chance of things, as yet not come to life, which in their seeds and weak beginnings lie intresured. Such things become the hatch and brood of time.

WHAT DO WE SPEND OUR MONEY FOR?

By Professor EDWARD L. THORNDIKE

INSTITUTE OF EDUCATIONAL RESEARCH, TEACHERS COLLEGE, COLUMBIA UNIVERSITY

It is obviously desirable to know what wants or desires are gratified by our uses of our time, energy and material resources. It would also be desirable to know what wants are gratified by our use of our abilities, interests, ideals and other mental resources; but since we do not use these up by using them, the problem is a different one. I have reported data concerning expenditures of time in the *SCIENTIFIC MONTHLY* of May, 1937. The present report concerns what we get for our money.

According to Lynd,¹ the people of the United States spent in 1929 8,000 million dollars for clothing, 1,500 million for laundry, cleaning and dyeing, 750 million for death and burial and 3,500 million for life insurance. We inquire how much of the 8,000 million spent for clothing was spent to gratify the desires for protection against cold, wet, animals, diseases, pain, for the reproduction of the human species, for pleasures of vision, for a happy sex life, whether by sensuality, romance, philandering, courtship or otherwise, for affection (i.e., to obtain it), for the approval of others, for self-approval, i.e., the sense of personal worth, for dominance over others, for the welfare of others and for any other desire which in fact led any person to buy clothing for himself or anybody else. We ask similar questions concerning the nation's laundry bill, funeral expenses and insurance payments.

It may be admitted at once that nobody can answer such questions accurately save by an enormous amount of careful and impartial observation of a representative sampling of persons in

¹ "Social Trends," Vol. II, p. 889.

respect of what they buy, what they do with it and what desires seem to be operating in the case of their purchasing and use. On the other hand, economists, business men, sociologists, psychologists and intelligent people in general are observing pertinent behavior constantly, and have a fund of facts which are far above zero knowledge and, we may hope, fairly free from constant errors of prejudice. It may be very useful to collect and organize samples from this fund.

This we have done, using as our retrospective observers eight psychologists (six men and two women), five women (including experts in nutrition, home economics and the family), three economists and a small miscellaneous group of intelligent persons. The opinions of this last group will be used only in part or occasionally as a check.

After some experimentation the list of wants shown as the headings in Table 1 was selected as representing fairly well the fundamental cravings and satisfactions of mankind, being fairly comprehensible to others than psychologists and being brief enough to make the organization and record of opinions fairly easy. Table 1 presents the estimates of the eight psychologists (there are ten records because two of the men made independent judgments after an interval of some months) concerning the allotment of 80 units of a hundred million dollars each spent for clothing. Table 1 also presents the estimates made by the five women, the three economists and two from the miscellaneous group. Table 1 is a fair sample of our data. It shows a wide variation in the amount allotted to any one want, part of which variation

TABLE 1

TWENTY ALLOTMENTS OF THE 80 UNITS (OF 100 MILLION DOLLARS EACH) SPENT FOR CLOTHING, BY EIGHT PSYCHOLOGISTS (p), FIVE WOMEN INCLUDING EXPERTS IN HOME ECONOMICS (w), THREE ECONOMISTS (e), AND TWO OTHERS (m)

	A. Hunger	B. Protection against cold, heat, wet	C. Exercise	D. Sleep, rest	E. Sex relief	F. Reproduce species	G. Protection against animals and diseases	H. Protection against bad people	I. Reduce or avoid pain	J. Pleasures of taste and smell	K. Pleasures of sight and sound	L. Sex entertainment	M. Security	N. Affection (to get it)	O. Companionship	P. Approval of others	Q. Approval of one's self	R. Mastery over others	S. The welfare of others	T. Mental activity	U. Curiosity and exploration	V. Social entertainment	W. Physical entertainment	X. Comfort not in A to W
p1a	30						8					5				15	10	10						
p1b	25						5					5		2		25	5	5						5
p2a	47						4					3	4	1	1	15	5	5						
p2b	40						10					20	6	6.5	4	5	5	5						
p3	30						10					7				12	10	5	4		1			
p4	30		.5	1			10					7				12	10	5	1		2		1	
p5	34						11					6				1	1	1	1				1	
p6	1 30						5	1				10	5	1	1	1	1	1	1		5		1	
p7	36						5					10	5			10	5	5					2	
p8	20	1			4		2					3	15	4	5	5	5	10	3	1	1	5		1
w1	40						3					10				10	7					10		
w2	35	1	1									10		3		10	5							
w3	15						3					8		5		8	5	5	8			15		1
w4	35	2	2		8		1					1	1	2	1	5	6	4	8			10	2	1
w5	40						1	1				5				10	6		5					
e1	14						2	3				10	10		5	15	5	10						
e2	40	1.6	1.6				16					8	1.6	1.6	.8	16	2.4	.8				4		
e3	20						2					10				40	8							
m1	64						2.4	2.4				1.6				4	3.2							2.4
m2	6						6					15		8		5	20	5						5

is doubtless due to errors of inaccurate observation, prejudice and inadvertence, but much of which is due to important differences in point of view and observations.² This variation is consistent with substantial agreements—of the psychologists *inter se*, and between them and the average of the other ten (the latter correlation being .85).

The only indubitable errors are the

² There is evidence in Table 1 and the thirty-two other similar tables (for food, rent, home-furnishings, fuel and light, etc.) that individuals impute to the general population desires unduly like their own and are somewhat blind to the existence and operation of desires which they lack and to behavior which is alien to them. Consequently, the estimates as a whole may err in the direction of a too intellectualistic, cultured and refined interpretation of the nation's expenditures.

following: Psychologist 4 and Women 2 and 3 assign nothing of the 8,000 millions for clothing to protection against animals and diseases, probably by sheer inadvertence, though they might argue that the clothes people wear do not demonstrably keep them from harm or increase their health. Misc. 2 assigns only 6 of the 80 units spent for clothing to the desire to avoid cold, heat and wet. This ratio of 1 in 13 could perhaps be true of city dwellers who live largely indoors and spend \$200 a year or more on clothing, but is surely far wrong for the many whose clothes cost less than \$40 a year, and too low for the average. Psychologists 1 and 4, Women 1 and 3 and Misc. 1 assign 0 to the pleasures of sight, whereas 3p, 6p, 7p, 2w, 1e, 3e and

2m assign 10 units or one eighth of the total to this. the former are probably wrong, neglecting the fact that a person may look at himself in mirrors and may buy good-looking clothes to gratify what he thinks of as the desires of others for pleasures of sight, rather than as his own desire for their welfare. The latter are probably wrong in imputing to the desire to have pleasure in looking at oneself force which belongs rather to the desire for approval, dominance and unspecified comfort, and in exaggerating the craving to give others beautiful objects to look at. They were probably too much influenced by the thought-sequence "clothes—to look well—pleasures of sight." These twelve errors more or less cancel each other, as often happens in our records. Apart from them there are only four indubitable errors in the 480 estimates.

I have searched all the allotments for laundry, cleaning and dyeing, death and burial and life insurance for errors. Of the \$150,000,000 spent for laundry, cleaning and dyeing, four persons allot nothing to the desire for protection against disease; seven allot nothing to the desire for pleasant smells; four allot nothing to the desire for the approval of others; four allot nothing to the desire for self-approval. These are all probably due to forgetfulness or neglect of certain facts of life. It is natural for refined persons who work in offices to forget about vermin, barnyards, babies and sweat. It is natural for scholarly males to neglect the tribute which clean clothes bring. These nineteen errors more or less cancel one another. In the case of the expenditures of 750 million for death and burial we may criticize one person's allotment of 350 million to social entertainment, and that of another who allots 400 million to the desire for affection. The amounts seem surely excessive. In the case of life insurance

an assignment of 500 million to the desire for company is probably a clerical error, the number being probably intended for the next box above, which is "Affection." The assignment of 0 to "Welfare of others" by two persons is wrong. These persons seemed to have endowment insurance and enforced insurance exclusively in mind and to forget that with the former the person is paying for possible benefits to others than himself. As in the case of clothing, errors are few and often compensating so that the average of ten or twenty opinions is fairly dependable.

Table 2 presents the average opinion of the two juries (psychologists and others) concerning what we spend our money for when we buy food, clothing, rent, life insurance, laundry, cleaning and dyeing, funerals and burial. The reader will note that purchases of *food* are judged to contribute appreciably to every one of the twenty-four satisfactions except protection against bad people, that purchases of *clothing* are judged to contribute appreciably to every one except the pleasures of taste and smell, and that *rent* is judged to contribute to all without exception. The reader will perhaps think that some of these allotments should be reduced to zero, because he himself gets no such gratifications from his payments, but he is probably wrong.

The table shows that the two juries agree rather closely.³ The psychologists tend to break away oftener and further from the conventional overemphasis on food for hunger, clothing for warmth, rent for shelter and insurance for security. Each entry in Table 2 has a certain interest, but we have more important facts to consider.

³ The closeness of agreement between the two juries is measured by the following correlation coefficients: food, .85; rent, .89; clothing, .85; laundry, etc., .79; life insurance, .71; death and burial, .84.

TABLE 2

AVERAGE ALLOTMENT (I) BY PSYCHOLOGISTS AND (II) BY OTHERS OF 1,700 UNITS SPENT FOR FOOD, 800 UNITS SPENT FOR CLOTHING, 800 UNITS SPENT FOR RENT, 400 UNITS SPENT FOR HOME FURNISHINGS, 480 UNITS SPENT FOR FUEL AND LIGHT, 350 UNITS SPENT FOR LIFE-INSURANCE, 150 UNITS SPENT FOR LAUNDRY, CLEANING AND DYEING AND 75 UNITS SPENT FOR DEATH AND BURIAL (THE UNIT BEING 10 MILLION DOLLARS). AMOUNTS ARE TO THE NEAREST UNIT, LESS THAN 5 MILLION DOLLARS BEING ENTERED AS 0

	A. Hunger	B. Protection against cold, heat, wet	C. Exercise	D. Sleep, rest	E. Sex relief	F. Reproduce species	G. Protection against animals and diseases	H. Protection against bad people	I. Reduce or avoid pain	J. Pleasures of taste and smell	K. Pleasures of sight and sound	L. Sex entertainment	M. Security	N. Affection (to get it)	O. Companionship	P. Approval of others	Q. Approval of one's self	R. Mastery over others	S. The welfare of others	T. Mental activity	U. Curiosity and exploration	V. Social entertainment	W. Physical entertainment	X. Comfort not in A to W
Food:																								
I	876	27	0	3	3	21	50	0	26	275	62	45	8	15	48	71	5	4	53	1	4	74	3	46
II	931	20	12	3	5	7	48	0	5	202	15	64	2	25	37	53	10	0	53	1	10	170	3	20
Clothing:																								
I	1	302	2	1	6	7	57	4	13	0	42	69	29	21	14	101	47	42	8	1	4	14	3	16
II	0	309	5	5	13	1	35	0	6	0	58	67	1	20	7	123	64	25	21	0	0	39	4	12
Rent:																								
I	15	235	4	94	22	20	37	36	3	4	21	21	80	16	18	48	28	13	28	3	1	31	3	17
II	8	250	1	66	9	17	36	30	2	3	40	25	35	13	10	78	44	6	31	2	2	48	6	39
Life Insurance:																								
I	0	0	0	1	0	17	3	0	3	0	0	2	73	23	5	29	48	2	143	0	1	0	0	0
II	0	0	0	0	0	10	8	6	3	0	0	2	168	12	0	3	8	1	124	0	0	0	0	7
Laundry:																								
I	1	6	1	5	1	2	26	0	1	9	14	13	1	0	1	25	18	3	8	0	0	4	0	15
II	1	3	1	0	0	1	12	0	3	9	21	5	0	4	1	32	20	1	9	0	0	8	3	11
Death and burial:																								
I	0	0	0	0	0	0	6	0	1	0	0	0	4	5	0	28	13	1	4	0	0	3	0	10
II	0	0	0	0	0	0	5	1	0	2	0	0	9	4	0	28	6	0	8	0	0	4	0	8

We may extend Table 2 by similar tables for the 33 items listed below, which represent Lynd's list with additions computed or estimated by Dr. Ella Woodyard (chiefly from various tables in *Business Week*, April 27 to September 7, 1932), and with certain items grouped.

ESTIMATED EXPENDITURES IN 1929 (IN UNITS OF 100 MILLION DOLLARS)⁴

1. Food	170	7. Religion	9
2. Clothing	80	8. Automobile (purchase and use)	65
3. Rent	80	9. Travel	20
4. Home furnishings	40	10. Motion pictures, theaters, concerts, etc.	20
5. Fuel and light	48	11. Clubs, lodges, etc.	4
6. Life insurance	35	12. Indoor and outdoor games, sports	9
		13. Newspapers	4
		14. Radio and musical instruments	6
		15. Jewelry and silverware	6
		16. Flowers from florists	2
		17. Cosmetics, beauty parlors	7
		18. Physicians	10
		19. Dentists	4
		20. Hospitals, sanitariums	11
		21. Medicine (patent and prescription and other medical costs)	10
		22. Laundry, cleaning, dyeing	15
		23. Tobacco	16
		24. Confectionery and chewing gum	7

25. Drinks and narcotics (not tobacco) —	27
26. Correspondence and communication —	10
27. Leather goods and luggage —	3
28. Investments —	95
29. Education —	16½
30. Welfare —	6
31. Death and burial —	7½
32. Legal services; fine, penalties, etc., including divorces —	3½
33. Taxes; local, state and federal —	64

If the 33 amounts assigned to each of the 24 wants are summed, we have estimates, by our twenty observers, of the total amounts paid to avoid hunger, cold, heat and wet, get exercise, sleep and rest, etc. These amounts and the percentages which they are of the total expenditures are presented in Table 3, which may be called a budget in terms of wants or satisfactions. The allotments by the two juries agree rather closely, the correlation (omitting X, miscellaneous satisfaction or comfort), being .92.⁵

Table 3 is much more dependable than any of the thirty-three separate tables whence it is derived. Imperfections in the allotments of one sort of expenditures by the two juries will be largely counterbalanced by contrary imperfections in the allotments of other sorts.

Table 3 states that we spend about one ninth of our money to ward off hunger, about one tenth to keep warm (or cool) and dry, that only a few eccentrics pay

⁴ The accuracy of the absolute numbers in these expenditures is of no importance to our argument. The accuracy of their relationships one to another is of importance, but not so much as would be thought offhand. The probability is that any reasonable estimate of the national budget of expenditures would produce about the same distribution among wants as this one does, with one exception. The year 1929 was more of a luxury year than the average, and to that extent our conclusions are somewhat biased against the necessities of food and lodging.

⁵ It would probably be higher if each person's X could be distributed among A to W.

TABLE 3
THE TOTALS OF THE 33 ITEMS OF EXPENDITURES
AFTER ALLOTMENT (I) BY THE PSYCHOLOGISTS
AND (II) BY THE GROUP OF ECONOMISTS,
EXPERTS IN HOME ECONOMICS, ETC.

	I		II	
	In units of \$10,000,000	In percentages of the total	In units of \$10,000,000	In percentages of the total
A. Hunger	1,018	11.2	1026	11.3
B. Protection against cold, heat, wet ...	925	10.2	889	9.8
C. Exercise	39	.4	63	.7
D. Sleep, rest	239	2.6	184	2.0
E. Sex relief	77	.8	81	.9
F. Reproduce species ..	172	1.9	73	.8
G. Protection against animals and diseases	404	4.4	377	4.1
H. Protection against bad people	227	2.5	140	1.5
I. Reduce or avoid pain	322	3.5	209	2.3
J. Pleasures of taste and smell	414	4.6	434	4.8
K. Pleasures of sight and sound	359	3.9	471	5.2
L. Sex entertainment ..	356	3.9	374	4.1
M. Security	959	10.5	1015	11.2
N. Affection (to get it)	163	1.8	169	1.9
O. Companionship	210	2.3	211	2.3
P. Approval of others ..	657	7.2	653	7.2
Q. Approval of one's self	367	4.0	347	3.8
R. Mastery over others ..	276	3.0	164	1.8
S. The welfare of others	656	7.2	786	8.6
T. Mental activity	175	1.9	210	2.3
U. Curiosity and exploration	168	1.8	211	2.3
V. Social entertainment	380	4.2	613	6.7
W. Physical entertainment	104	1.1	115	1.3
X. Comfort not in A to W	411	4.5	273	3.0

money for exercise, our payments for games and sports being for entertainment rather than exercise, that we spend much time but little money for rest, that the mental features of sex life cost us about five times as much as the physical, that the reproduction of the species comes chiefly as a by-product, that we pay twice as much for protection against diseases as for protection against bad men (or did in 1929), that sheer sensory pleasures and the avoidance of pain (exclusive of hunger, cold, heat, wet and fatigue) account for only about one eighth of our budget. Some Freudian psychiatrists say that what human beings want above all else is love and

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security, but in Table 3 security averages under 11 per cent. and affection under 2 per cent. We pay more to get companionship than to get affection. Approval of others and of one's own self (conscience, self-respect, pride, etc.) rival hunger and security. A cynic may say that the percentages for Item S (the welfare of others) in Table 3 show modern civilized man to be only one twelfth altruist and that the percentages for item T show him to be only 2 per cent. intellectual. This is harsh, neglecting the time that persons (mothers especially) spend for the welfare of others, and the fact that a fine intellectual life can now be lived at almost no pecuniary expense, and also neglecting certain facts of Table 3 itself. But Table 3 does fall far below the ideals set by moralists. For entertainment (L, V and W) we spent more than for mental ability and the welfare of others combined.

Table 4 shows the allotments to vari-

ous groups of wants, compiled from Table 3. Less than a third of the expenditures are allotted to keeping the population alive, well and able to reproduce itself. The pleasures of the senses take a tenth; the pleasures of the intellect less than half that. The selfish satisfactions which depend rather directly upon our fellow men take over a fifth. This becomes over a third if the satisfactions of the love-life and benevolence are included. The desire for security takes a tenth, an eighth if security from bad men is also included. By Table 4, Homo (of U. S. A. 1929) seems much more sociable than sapiens. He seems to be mainly a hedonist, but most of the pleasure he seeks is not of the senses.

Tables 3 and 4 are subject to correction and improvement, but they give, I think, a better picture of the ultimate satisfactions for which those with purchasing power use it than has hitherto been available.

There are two feasible ways to correct and improve the picture. The first is to follow the method used here, but with other and possibly better measurements of expenditures, with other and better lists of wants, and with larger juries of psychologists, economists, business men and specialists, familiar with the behavior of consumers, white and black, in city and country, north and south, rich and poor. Our twenty judges may have a constant error in the direction of exaggerating such satisfactions as they themselves and their friends and acquaintances feel and pay for, and so underweighting the influence of the vulgar rich, the wretchedly poor, the very dull, the mean and cruel, the dwellers on farms, etc. It would be especially useful to have allotments made by wealthy persons and by social workers who are familiar with what the poor buy and why

TABLE 4
THE TOTALS FOR GROUPS OF WANTS, COMPUTED
FROM TABLE 3 AND EXPRESSED AS
PERCENTAGES

	I By psych.	II By others
Subsistence, perpetuation and some increase of the stock (A, B, C, D, E, F and G)	31.6	29.6
Pleasures of the senses, bodily ac- tivity, intellect and love life (I, J, K, T, U, W, L and $\frac{1}{2}$ X)	23.3	23.8
Security (H and M)	13.0	12.7
Social satisfactions (N, O, V, P, Q, R and $\frac{1}{2}$ X)	24.8	25.2
Benevolence (S)	7.2	8.6
Total	100.0	99.9
Subsistence, etc. (A, B, C, D, E, F and G)	31.6	29.6
Reduced pain (I)	3.5	2.3
Pleasures of the senses and bodily activity (J, K and W)	9.6	11.2
Love life (L)	3.9	4.1
Pleasures of the intellect (T and U)	4.0	4.6
Security (H and M)	13.0	12.7
Company, affection and social enter- tainment (N, O and V)	8.4	10.9
Approval, social and self (P and Q)	11.3	11.0
Mastery or dominance (R)	3.0	1.8
Benevolence (S)	7.2	8.6
Comfort not included in the above (X)	4.5	3.0
Total	100.0	99.8

they buy it, and to estimate from these the magnitude of this possible error.

"What we spend our money for" may be translated into "What we spend our working time for," and then combined with the facts reported in the earlier article about our uses of leisure. The combination will give some idea of the gratifications for which all our days are spent.

Time not spent at work or sleep was found to be spent largely for entertainment (including the pleasures of the senses and of the love life), companionship, affection and approval. Much of working time also is spent for these. I estimate that about a third of waking hours are spent for entertainment in this broad sense, about a tenth for companionship and affection and about a tenth for the approval of self and others. Generous estimates of the use of leisure time for intellectual activity other than for entertainment and for the welfare of others would be around one twentieth in both cases. This would give for all working hours about 4 per cent. for intellectual wants and about 8 per cent. for the welfare of others.⁶ Most people

devote few or none of their leisure hours to the security which is a main purpose of their work. The total is about 7 per cent. The needs of subsistence, perpetuation and some increase of the human race in this country account for about a fourth of our waking hours.

I conjecture therefore that the 16 hours of the waking day of adults in the United States are spent roughly as follows:

25 per cent.	for subsistence and perpetuation.
2 " "	to avoid or reduce sensory pain.
7 " "	for security.
8 " "	the welfare of others.
30 " "	entertainment.
10 " "	companionship and affection.
10 " "	approval.
4 " "	intellectual activity.
2 " "	dominance over others.
2 " "	other wants.

These allotments are easy to criticize. I myself could put down reasons why this or that one is probably wrong. But they are at least honest, impartial conjectures based on facts.

⁶ This estimate is specially insecure because the budgets of time include none for mothers. I have had to guess what allotment to make for them.

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AN ADVENTURE IN ETYMOLOGY¹

II. MEANING IN BIRD-NAMES

By ERNEST INGERSOLL

NEW YORK, N. Y.

THE giving of names to animals is as natural as attaching them to hills and rivers. It was one of the first products, no doubt, of the practice of human speech and remains a characteristic of every dialect into which speech is now diversified; moreover, the nomenclature of natural history has grown up everywhere in the world, ancient or recent, in strikingly uniform lines of development. Names, in fact, are mere labels—aids to memory and means of arrangement and record. As did the most primitive people, so subsequent explorers and settlers in each new region seize on what at the moment seems the most striking feature in each animal or object they encounter; and their designations often stick forever, however erroneous they are later found to be.¹

Most birds owe their names in everyday speech to one or another of four noticeable features: (1) color; (2) voice; (3) form, as a whole or in detail; (4) some striking peculiarity in method of life. Occasionally two characteristics are combined, as in "bluejay," which expresses both color and voice. Many of the present names of our American birds, especially those of generic breadth, are modernized forms of ancient English words of Scandinavian or French parentage or of so remote a foreign origin that their primitive significance can hardly be guessed; nevertheless, a queerly disguised and even amusing parentage will often reward search. The term "bird" itself, for example, is sister to "bride," and both contain the implication of a brood.

Readers will now perceive, by recalling the four classes of name-source just mentioned, that birds are commonly known by names so matter-of-fact and obvious as to need little or no explanation: the red, black, and blue birds; those that tell their own names, as killdeer, bobwhite, chickadee; those of familiar habits or flight, as woodpecker, hummingbird, etc. Also, it must be remembered that a long list of American species and subspecies recognized by scientific ornithologists, and recorded in international classification, have no "common" names at all. Thus space is left free to be devoted to that minority of our feathered friends of the forest, the meadow, the garden and the water-spaces. These bear labels the origin and interpretation of which may henceforth engage attention. I shall lead the inquiry in a general way, as a matter of convenience, along a line partly of popular interest in birds and partly of modern classification; therefore I make no apology for beginning with the birds of prey.

The names of few American raptorial birds require explanation. These hunters of the air fall into five groups: Eagles; Buteos (buzzards) and harriers; Falcons, long-winged, heroic hunters; Fishhawks; Kites. The broad word "hawk" is the old Saxon *hafoc*, a killer; the largest of the race are the eagles, and of these the grandest is the golden eagle, Bird of Jove.

Eagle is the Latin *aquila* transformed into English by aid of the French *aigle*. An Irishman with a fair brogue reproduces the word's birthstory when he cries the toast:

Here's to the American Aigle,
Whom none can invaigle,
Nor put salt on his beautiful tail!

¹ SCIENTIFIC MONTHLY, 44: 2, 157, February, 1937.

The original English name of this bird was the widely spread northern word *earn*, which has become useful as "erne" in dialect poetry and in cross-word puzzles. Our national emblem, the "bald" eagle, owes its misnomer to the cap of white feathers on the head of adults; it is, as Benjamin Franklin told Congress, when it was proposed to put it on the seal of the new United States, "a bird of a bad moral character"—a shameless bandit. Far nobler is the species we call "golden" because of the golden gloss that suffuses the feathers of the neck when mature; and far better had the name "war-eagle" been popularized for it, and had its image been engraved on our seal instead of that of its less worthy cousin. Such a distinction would have been appropriate, too, because this bird was the war-eagle of the Indians—America's natives—and was held in almost divine respect. This noble eagle is a resident of the whole northern hemisphere, and its history as a warrior is equally broad, for it has figured as a symbol of imperialistic pride and power from the rise of Babylon to the fall of Rome.

The Buteonine group contains what Europeans style buzzards, originally a medieval sportsman's expression for an inferior kind of hawk as used in the chase. Most of the short-winged hawks, so called in this country, are the "red-tails," "broadwings" and their like, which are the "henhawks" of rural complaint, though most of them are almost innocent of attacks on game or poultry. Guilt in this respect belongs mainly to the small accipiters, such as the sharpshin (J. G.) Cooper's hawk, the goshawk (i.e., goosehawk) and in a minor degree to the marsh "harrier." These keen, swift hunters of living prey introduce the falcon type.

Falcons are the true birds of prey. They take their ancient name directly from the sickle-like (Lat. *falx*, a sickle)—curvature of both beak and talons—instruments of grasping and tearing power closely like the teeth and claws of cats;

and they do in the air exactly the service nature requires of tigers and wildcats on land—destruction of the weak in favor of the strong. The term "falcon" came into Britain when "the sport of kings" was brought in the trail of William the Conqueror. At first it belonged to the peregrine (our "duck-hawk") and strictly meant the female. Two other old sporting names frequently met with in books are merlin and kestrel; the former is represented by our pigeon-hawk, and the latter by our sparrow-hawk.

Falconry, or hawking, as the English prefer to style the sport, brought with it an extensive and special vocabulary, much of which is obsolete. The terms designating the trained birds themselves in their various ages or in the phases of their work seem to me worth recounting because some of them recur often in histories or novels. Falconers spoke of a hawk lately from the nest as an eyess; when able to take game as a soar hawk; a mature wild hawk they called a haggard or blue hawk. A male falcon was called a tiercel or thirdling, from the belief that a bird produced from the third egg laid in a clutch would necessarily be a male.

Our *Fish-hawk* is the same as the bird known in the Old World as osprey, which name is a compound of two Latin words equal to "bone-breaker"; an older form used in the Bible (Lev. xi: 13) is ossifrage. As the fish-hawk (osprey) is rare in Bible lands, and does not break large bones, it is probable that the great alpine vulture, the lammergeir, was the bird really referred to by the sacred writer.

Kites were almost as numerous in and about London in the seventeenth century as are sparrows now, and were valued and protected by law and custom as scavengers; the name is plain A. S. *cyta*. The flying toy that we send up on a breezy day came to be called a kite (after its introduction to British youths about 1650) because in the air it resembled the sailing and poisoning of the graceful bird; it is in reference to this elegance on the wing

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that Chaucer and other early poets call a kite glede or "glider."

The American vultures have been unfortunate in this direction. The great Andean-Californian vulture was called *Condor* in a fairly close Spanish pronunciation of its native (*Cuntur*) name in Peru. Ignorant colonists in some southern colony inflicted the quaint compound *Turkey-Buzzard* on the larger of the two vultures in the United States, and called the lesser one *Carrión Crow* in misguided recollection of the carrion crow of Britain—a very different sort of fowl, destructive and disagreeable. This brings us to consider the gallinaceous tribe.

The popular names of game-birds are amazingly mixed, and carry much of history and romance. The *Pheasant*, so carefully preserved in Britain, is of a species native to the region northeast of the Black Sea (the ancient Colchis), and took its name from the river Phasis there, whence the first specimens were brought to Greece and thence spread over Europe long ago. That pheasant lately acclimated in North America, the "ringneck," represents one of the many other species of Phasianidae in India and China. The domestic *Turkey* is a descendant of some variety of the bronze turkeys of southern Mexico sent alive to Spain in 1630 by the conquerors of that country. When, later, this fowl spread in captivity to other parts of Europe, few knew whence it originally came—some said from India (the French still call it *coc d'Inde*), others said from Turkey. The last guess got the lead in England, so that when these fowls were brought to America by the first British colonists they came as "turkeys."

Grouse meant originally a gray bird (German, *graus*). Our grand, drumming, woodland species is distinguished by a "ruff" of erectile feathers upon its neck, which northern fur-traders used to call shoulder-knots or sometimes tippets. In New Brunswick, Maine and southward

to Pennsylvania, this ruffed grouse is commonly known as "partridge"; further south it is a "pheasant" or "mountain pheasant." *Partridge* is the most abused word in American bird-talk—abused in form, spelling, pronunciation and significance; it is a distorted descendant of *perdix*, denoting in ancient Greece and Italy the small, gray, European game-bird introduced to us recently as "Hungarian partridge." That species is a cousin of the American quails, but our bird—the "bob-white"—is so different from the European type that properly it is not even a true quail, but must be classed with the Mexican colins; nevertheless, all over the north bob-white remains a *Quail*, and everywhere south of Maryland it is equally sure of being reported as a partridge—just the reverse of the way "partridge" and "pheasant" are separated.

Ptarmigan is the English spelling (since 1684) of the Gaelic word *tarmachan*, meaning white game, applied by Scottish shepherds to a northern, mountain-dwelling variety of the red grouse, a moor-fowl, which turned white in winter. When Scotsmen began to flow into Canada, and especially into the Northwest, they found there virtually the same white grouse and naturally called them ptarmigans.

Our *Prairie Chicken* has escaped the name partridge. It is the so-called "pinnated grouse." This fine bird was encountered by the first Puritan settlers in Massachusetts wherever open country favored its presence, and it was given the appropriate name *Heath-Hen*, which was retained by its survivors on Nantucket until its extinction in 1932.

The heath-hen in early days abounded on the plains of Long Island, New York, where, in 1791, a law was passed by the State legislature for its protection by a close season between April and October. A footnote in Brewer's edition of Wilson's "Ornithology" records a ludicrous incident that occurred during the discus-

sion of this law, which was entitled "An act for the Preservation of the Heath Hen." The chairman of the Assembly—no sportsman, evidently—read this title as an Act for the preservation of the Heathen, which astonished the more northern Representatives, whose particular "heathen" were the still troublesome Indians of the Adirondacks. . . . The modern designation Prairie Chicken for this fine grouse is appropriate; and it is a vast pity that some pedantic classifier tacked upon it the awkward name "pinnated," as if the tufts of feathers beside its neck were wings!

Pigeon is an example of the strange changes that happen to an every-day appellation and its significance in its descent from the Latin (not to go further back) through medieval talk until established by dictionary makers into a modern form. Our English pronunciation differs little from the French or Spanish, but how *dg* or *ch* sounds, in all three languages, were derived from the Latin verb *pipio*, to pipe (in music) or to peep (as young chickens) is hard to understand. In Italy this bird is now *piphione*, literally a young pigeon, a "peeper." Among us the word pigeon is virtually restricted to the domesticated varieties of the European bluerock and related pigeons of large size; but specifically it means in this country the native migratory or "passenger" pigeon, now extinct.

Dove is the original English name for the birds of the family Columbidae, and represents the very ancient Germanic form *dufa*, a diver; the essence of the Latin word *columba* is "diving." How this significance came to be attached to birds of a purely terrestrial nature seems beyond accounting for. The old-fashioned word "culver" for dove, regarded as a short and altered form of *columba*, has a place in archaic poetry, such as that of Chaucer, and is still heard in British provincial speech, as, also, are the Scottish words "cushie-do," or "cushat" for the ringdove, which refer, it is said, to its

peculiar swift, straight flight. Our common eastern wood or "mourning" dove is frequently miscalled "turtle-dove," a term that belongs properly only to the small European species that the Latins spoke of as *turtur* in imitation of its soft cooing. The fact that our forefathers mispronounced the Latin word into "turtle," and so printed it in the English Bible, has made a comic confusion in the minds of devout but ignorant readers who do not know the difference in origin between the name of the bird and that of the reptile, the latter a rude corruption of "tortoise."

Owls and goatsuckers fall nicely together ornithologically and in our lexicon. Both are nocturnal in habit and are alike equipped with large eyes, soft, loosely knit feathers, big mouths and a strong desire to fill them. Few persons need be told, I believe, that *Owl* is simply a Cockney shortening of "howl"; an old owl is a howler, a young one a howlet. There is a story that a Londoner, scared in Canadian woods by an unearthly noise, was told: "It is only an owl." He responded: "I know it's a 'owl, but wo't in 'eaven's name is that 'owlin?" Thus a stranger had been introduced to the great, horned (not great-horned) terror of our forests, otherwise the cat-owl. Its body is great, but its "horns" are relatively small, and its upstanding crown-feathers should be called tufts, not horns or ears, as they are in smaller related species of this widely varied family.

The "hoot" owl of books is the barred species, locally rain-owl; the short-eared is the marsh or prairie owl of farmers; the saw-whet takes its quaint name from its chant, which reminds one of the filing of a saw, while its variety has become a sparrow-owl in the west; our barn-owl is identical with the British one, but has different habits and is rarely seen by those not looking for owls. "Screech-owl" is an ancient but very indefinite designation. Certainly the term ought not to be used in this country as it con-

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stantly is for our little red and gray crooner, because the gentle, wavering serenade with which he lulls us into sleep is the very antithesis of a "screech." Quebec people describe this bird of the moonlight as *le hibou macule*, and "mottled" would be a proper name for this small species, which is almost a replica of the little Grecian owl (*Athene noctua*), the special cognizance of the wise and stately goddess of the Athenians in their prime—Pallas Athene.

Goatsuckers, of the classically styled family Caprimulgidae, have rested for ages under a false and foolish label. Greek shepherds on Thessalian hills accused these birds, 3,000 or more years ago, of milking their goats in the night. I wish to drop this silly and libellous name from American currency and to put in its place *Nightjar*, borrowed from an English species, whose song is likened to the noise of an old-fashioned spinning-wheel. Our representatives of this family are the various whippoorwills and their cousins, the nighthawks, which latter have received that name among us because they resemble small falcons when they swoop and dodge in the twilight as they pursue their insect prey through the air overhead. At such times they utter a whirring, booming sound, which has given them in the southern states the nicknames "bullbat" and "piramadig."

Swifts are a cosmopolitan family renowned for marvelous evolutions in flight. We have a few species in the United States, the most conspicuous of which is the occupant of our chimney-stacks, commonly but wrongly called "chimney-swallow." In Europe swifts used to be known as martlets; and this word is employed in British heraldry to denote a footless bird—a figure borne on the escutcheons of certain old families. The notion arose from the tiny form of the swift's feet; but why they were also

classed among "devil birds" is a mystery.

Hummingbirds took that name, of course, from the sound made by their rapidly moving wings. The first recorded notice of our eastern one, the ruby-throated hummer, occurs in a christening letter from John Winthrop, Colonial Governor of Connecticut, dated October 26, 1670, in which he mentions sending to a friend in England "the curiously contrived nest of a humming bird," so called, he explains, "from the humming noise it maketh while it flies." The Carib Indians told Columbus these birds were "colibri," and that name still exists in some of the West Indian islands. Imaginative Portuguese in Brazil have invented, or borrowed from the native Arawaks, such fanciful pet-names as flower-peckers, flower-kissers, myrtle-suckers; and the Peruvians and Mexicans have styled them rays of the sun, tresses of the daystar, and the like, and declare that they subsist on dew.

Woodpecker, as a name, is self-evident. In the southern states the absurd rendering "peckerwood" is heard, and there, especially, the giant of the family is a "logcock." Carpintero is the good Spanish name for all these birds in California and southward. "Sapsucker" is often carelessly applied to any small woodpecker, but rightfully belongs only to the yellow-bellied, brush-tongued species of the American genus *Sphyrapicus*, which in spring pierce the outer bark of trees to get at the bast, soaked with sweet sap. Who first coined the nickname "flicker" for the ubiquitous golden-winged woodpecker is unknown, but it fits fairly well the repeated shout of this fine species as it flies from place to place, and has generally replaced a large number of insignificant local names, such as pigeon-woodpecker, highhole and yellow-hammer. The last mentioned would appear at first glance to be simply "yellow

hammerer," but really it is a misplaced borrowing of the name given in England to any of several small birds more or less yellow in plumage, combined with the ancient Icelandic word *hamr* for skin—in other words a "yellowbird."

Cuckoo, now the application of a world-wide and surprisingly varied family of birds, simply repeats the spring-call of the European parasitic species, which thus conferred both name and reputation on its tribe. The two related American species make a stammering attempt at the British pronunciation but fail, nor are they parasitic. The *Roadrunner* or chaparral-cock of the Southwest belongs in this family, as also the *ani* (ah-nee) or mangrove-cuckoo of the Caribbean region. In the southern states our cuckoos are usually spoken of as "rain-birds." Why? When our remote forebears were talking and writing "Sanscrit," in northern India, among the nature-spirits in their religious scheme the Indian cuckoo was a mixture of symbol and practical ruler of the clouds and rainfall. The people did not distinguish very well between the symbolic or spiritual image and the actual bird—imagined their living cuckoo to be an inspired prophet in the all-important matter of rain. This reputation has descended to and been fastened upon all the cuckoos in the world, making them "rain-crows" everywhere.

Kingfisher. This seems an obvious label to any one who knows our belted representative of this extensive family, and was perhaps suggested by the bold way in which he controls what he has preempted as his part of a stream or lake-shore. He has inherited from his European relative the name *Alecyon*, which is frequently used as a synonym by writers of essays and poems here, thus connecting our bird, quite improperly, with the romantic traditions and fables of "halecyon" classic days, and with medieval tales and practices. These

reminiscences, in which Old World fact and fable are curiously interwoven, I have retold and considered at some length in my "Birds in Legend, Fable and Folklore" (New York, 1923).

Lark is a word so old and altered that no one knows its original sense. It is traceable to the Anglo-Saxon *lawerce*, the skylark, and is retained in Scottish speech as "laverock," a word constantly occurring in the verses of Burns and earlier poets. In the sixteenth century the spelling "lerck" prevailed, but the pronunciation then doubtless rimed with park. We have no true larks (*Alauda*) in the United States, except the widely distributed shore or "horned" lark, the latter name referring to the black, slender, erectile feathers on the side of the head. The so-called titlark and skylark of the western plains resemble true larks in form and singing, but are classified as pipits. The familiar "meadowlark" of this country is an associate of the orioles and marsh-blackbirds (*Icteridae*).

Flycatcher in American ornithology denotes a small bird whose food consists of insects caught on the wing, except that fed to nestlings. All our species belong to the wholly American family *Tyrannidae*, long ago styled tyrant-flycatchers, with special reference to the bold, pugnacious behavior of the *Kingbird*. He royally defends his nesting territory against every intruder, and occasionally steps beyond kingly courtesy to harass crows, hawks and cats coming near his throne in an apple-tree. Southern farmers declare him a "bee-marten," but he does not deserve the charge that he injures their hives. Laymen speak of the small, woodland flycatchers as "pewees"—a rough imitation of their plaintive calls; but the phebe (not Phoebe) and the chebec call their names clearly, asserting their individuality. Another and different sort of flycatcher, however, the *Scissortail*, exists in the Texas region. It is a beautiful white, pink-trimmed little

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creature, with a distinguishing ornament in the two central tail-feathers, each eight to ten inches long, that float behind it as it flies. They spread and close at will, and do suggest the opening and shutting of a pair of scissors.

The word *Swallow* has suffered only trifling change from its ancient Scandinavian source, which seems to have been an attempt to express the swallow's swinging, to-and-fro, manner of flight—a "tossing" as of a ball by two players. The many northern species are designated, some by color, others by habits, and do not need explanation except, perhaps, as to the name *Martin*, which some of them bear. This term is an interesting introduction from France, and belongs to European history, for it recalls that good bishop of Tours (fourteenth century) who has become the patron saint of France. His feast-day, called in England martinmass, is on November 11, by which date most other small birds have fled toward the south, but this household swallow remains, as if to participate in the day of honor and so has come to be known as St. Martin's bird. It is not surprising that this insect hunter should stay late in France, for in southern Europe this is the pleasant season of the year that the French call St. Martin's summer and we Indian summer. Our large and friendly swallow, the "purple martin," has inherited the name, if not the pious repute.

Most of us would declare offhand that our bluejay is so called in imitation of its raucous shout which cheers us in autumn, but that is a bad guess, like so much else in popular etymology. The family name *Jay*, as we have it, originated in Italy. Passing into old French as *gai*, meaning gay, it became modified in recent French and Middle English as *geai*, with the initial softened and replaced by *j*; but the Spanish *gayo* retains the hard *g*. The word is an adjective proper to a bird having as bright a dress and lively

manners as belong to most of this conspicuous family. The proper name of our eastern American representative should be jay-bird or better jaybird (one word), as is the custom in the southern states. West of the plains many other species exist, each named from its color or habitat or in personal compliment—for instance, the long-crested or "Steller's" jay of British Columbia, first brought to scientific notice by William Steller, the earliest naturalist to visit the northwest coast.

Of particular interest to northern residents is a rather distant cousin of the bluejay—the *Canada Jay*. Unlike its gay southern relatives it is garbed in sober grays and shows none of their swaggering behavior or banditry, but in the friendliest way it seeks the camp of the lonely traveler in the forest and the dooryard of every Canadian lumberman or pioneer, to be welcomed as an amusing guest or playfully sworn at for its impudence. Hence has arisen a long list of nicknames—moose-bird, meat-bird, camp-robber, deer-hunter (California) *le geia du Canada* (Quebec) and most popularly, in and out of books, "Whisky Jack." The last epithet is an anglicized form of the bird's name among the Indians speaking in Algonquian language and varies with tribal dialects—in Nascapi "uscachon," in Montagnais "uiskestian" (Comeau), in Cree "wiscachon" or "wiskichannis," and so on. Pronounce any of them and you will not wonder that the explorers of the northern forests instantly twisted one or all of them into Whisky John and then improved it into "whiskyjack."

Nearly all the crow-tribe reveal their names in their hoarse croaking and cawing, regardless of our spellings. This fact is hard to recognize in such words as rook, chough, daw, disguising three common European members of this sable-suited family, yet they are traceable to primitive attempts to translate the utter-

ances of these birds. Entirely different in origin is the Scotch and Welsh "corbie," which is now used for the carrion-crow, hated by farmers and gamekeepers for its destruction of young lambs, broods of game-birds, and its carrion-eating propensity. This opprobrious epithet was first given in very early times to the raven, and it came from the Anglo-Saxon root-word *gor* (gore) signifying clotted blood and hence filth, as of a dead animal; and when the persecuted raven had disappeared from most of Britain the name was attached to the carrion-eating crow, and sometimes to the gray-backed crow or "hoodie," which is not much better.

The name *Raven* is now generally believed to have its source in the ancient verb to raven, tear, despoil, thus identifying this ominous bird with the scenes of battle, rapine and death with which our ancestors were sadly familiar not so many centuries ago.

Three lesser British members of the Corvidae, the rook, chough (pronounced "chuff") and daw are also self-namers, the last-mentioned now usually referred to as "jackdaw" in a spirit of amused contempt, for the "jack" in its name means "little." English literature is full of references to these birds, which leads me to bring them into this essay.

In North America, besides our various crows and ravens, we have two nearly related species deserving notice—the *Maggie* and the American Nutcracker, the second popularly known in the West as Clarke's or, better, gray crow. The latter is an inhabitant of the Rocky Mountain region, and was named after Captain William Clarke, co-leader of the famous Lewis and Clarke expedition across the continent in 1804-6, whence the first specimen was brought to scientific attention.

"Pie" is an old word, not much in use here, applied to birds, flowers and so forth which show color in blocks of contrasted hues, that is, are not striped or

mottled; such are said to be "pied," and the *maggie* is an excellent example. The "mag" part of its name is evidently a short form of the French word Margot, and is just a friendly tag like Tom-tit or Poll-parrot. Shakespeare uses it in *Macbeth*, III; 4:

Augurs and understood relations have
By magot-pies and choughs and rooks brought
forth
The secret'st man of blood.

I fancy, however, that in the minds of most Englishmen, and of ourselves, the "mag" is a rough abbreviation of Margaret, and the bird, whose associations, actual and mythical, are, to say the least, mischievous, is thought of as a demirep female-relative of Jack Daw.

All our blackbirds, orioles, meadow-larks, etc. (except the bobolink) of the family Icteridae, bear borrowed names. The blackbirds generally were at first styled "American starlings" and "troupials," the latter an anglicized word meaning flocks. These were book-names, but practical farmers knew them as "corn-thieves," "redwings," "yellow-heads," and called all the bigger kinds "crow-blackbirds" or "grackles." A recent author tells his readers that the *Grackle* came to be so called on account of its harsh voice, but this is a mistake; that word is a clipped form of the ancient Latin name of the jackdaw. Early European ornithologists transferred the generic term, as *gracula*, to the starlings of India, particularly the sacred myna of the Hindoos, and early American writers borrowed the term for use here when our blackbirds were mistakenly classified as starlings.

The true *Starling* (European), which is fast becoming naturalized among us, brought its name with it, which is a diminutive form of the Anglo-Saxon *staer* modified at first into "stare" (still used), and then into "sterling" and

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finally starling. Its nearest native counterpart in this country is the *Meadow*-or old-field lark. This bird is not at all a lark, however, although similar to one in habits and voice, and in the mating season often may be seen and heard flying high in the air over its nest and singing to its mate as if it really were a large skylark.

This brings us to the *Oriole* group, whose name has come to us by way of the French from the Latin *aureus*, golden, so that when some one speaks of our favorite summer visitor as "golden oriole" he is, as it were, painting the lily; to say "golden robin" is bad in another way. Our American orioles belong to a different family from their namesakes in Europe and the East, in spite of close external resemblance. Our most familiar "hangnest," at least in the eastern provinces, is the Baltimore oriole. This species owes its name to the great systemist Linnaeus, who desired thus to compliment Lord Baltimore, founder of the colony of Maryland, from which that naturalist had received a specimen-skin. Linnaeus regarded the bird as uncatalogued, and therefore, in 1766, named it *Oriolus Baltimore*, in allusion to that gentleman's ancestral colors, yellow and black; but Mark Catesby had described and pictured it long before (1731) in his book on the Carolinas under the name Baltimore-bird, bestowed for the same polite reason! Bullock's oriole represents almost exactly the Baltimore-bird on the Pacific Coast, and is a great favorite in California.

Bobolink got its cheerful nickname from the attempt of New England colonists to capture its song. Some Puritan ear happily caught these syllables, and everybody adopted them as they do a "catchy" tune. Nuttall and other ornithologists have devoted pages of their books to imitations in print of the merry fellow's tinkling prattle, only to show that words and syllables can't do it.

It is the jazz in the spring concert. Some poems have come nearer to expressing the jolly melody, notably one by J. T. Trowbridge. When the meadow-courtships are done with, the resulting eggs hatched, and the black-and-buff uniforms of the erstwhile singers have become rusty brown by wear, the bobolinks and their families drift away southward to become "reed-birds," shot along the southern coast by hundreds of gunners (but less than formerly). After running this gauntlet the depleted flocks move on to the few remaining rice-fields, where, as hated "rice-birds," they are so persecuted that relatively few of the little migrants ever live to reach the safety of winter quarters in South America.

BABES IN THE WOOD

Now we must give a little space to a company of small, distinctively woodland birds often seen together—a related, co-operative group of insect-hunters and caterpillar-catchers familiar to all observers in rural districts—titmice, nut-hatches and creepers, with which may here be associated, for convenience, gnat-catchers, kinglets and dippers.

Titmouse. Tit is an ancient word for "little" (A. S. *tita*), particularly indicating a tiny bird; hence "titling" (the British hedge-sparrow), titlark, etc. The second syllable, mouse, simply indicates the grayish color and mouse-like behavior of the small and active birds that bear it. To carry this whole name into a plural tit-mice is, however, very misleading, for it turns the birds into "little mice"—which they are not! Undoubtedly the plural form should be titmouses—but it is too late (and awkward) to make it so, and it is best to forget it and call the whole tribe *Chickadees*, which they themselves ask us to do in their cheery calls to one another. This call, in the case of western species, is less distinct than is heard in the East, so that Californians call them "Bush-tits," and the related,

yellow-headed bird in Arizona gets the Spanish name *Verdin* in reference to its greenish-ashy dress.

Nuthatch, i.e., nut-hacker, is borrowed from abroad, where it is much more applicable to British than to American species.

The *Brown Creeper* of our woods bears a name perfectly descriptive of this silent little creature as it travels mouse-fashion up and down the tree-trunks, exploring every crevice for insects and their eggs.

Gnatcatchers are in habits southern fly-catchers.

Kinglets, the smallest American insect hunters except the hummingbirds, appropriately wear a half-hidden "crown" of golden or ruby feathers in each of our two species.

The American *Dipper* ("diver") or *Water Ouzel* (water-thrush) is practically the same as the European bird of that name, but its habits are different from those of the foregoing tree-haunters. It is numerous among all our western mountains wherever streams flow, near which it passes most of its life, its exquisite, prattling song charming all listeners.

Wren is almost unchanged from the oldest usage and spelling traceable, and only two of our eastern specific names call for notice—one is Bewick's wren, discovered and named by Audubon after Thomas Bewick (1753-1828), the famous English artist and engraver; the "winter" wren was so called because Wilson, Audubon and the early-describers, generally, lived in the southerly parts of the United States where it was visiting migrant from the North. Next to the almost universal "house wren," the "Carolina" or "mocking" wren of the southern states most deserves remark, as it stands as intermediate between the little wrens proper and their larger relatives—the mockers of the allied family *Mimidae*, embracing the celebrated *Mockingbird* of the South, the widespread mewing *Cat-*

bird and the big *Brown Thrasher*. All three are magnificent singers, and we used to call them thrushes until the anatomists interfered. Whether any of them are really self-conscious mimics is still a matter of dispute in which this writer inclines to the negative side of the argument.

Thrush is a word of unremembered origin which appears in various forms in every Indo-European language. An ancient variant survives in "throstle," common in England for the song-thrush (German, *drossel*), which in Scotland is known as mavis, said to be of Spanish derivation.

Turning to American thrushes, I have not been able to discover what imaginative person gave the adjective *Hermit* to that adored songster, but probably he was among the readers of Alexander Wilson's "Ornithology," in which this thrush was first really described, although the bird had been noted in Carolina by Catesby (1731-48) somewhat earlier, under the name "little thrush." "The dark, solitary cane and myrtle swamps of the Southern States," says Wilson, "are the favorite haunt of this silent and recluse species." Therefore he introduced the new species as *Turdus solitarius*. The names of few other thrushes need remark: "Veery" is an expressive label to the distinctive character of its sweetly rolling music; Bicknell's thrush commemorates E. P. Bicknell, a naturalist of the Hudson River group; "varied" thrush is the book name of a Pacific-coast species better known as Oregon robin. A thrush in the West Indies, and another in British Columbia, noted for wonderful voices, are called "solitaires" because of their shy residence on remote mountains, and the *solo* method of each of these musicians. The best known of all, and most often seen and heard, the big, arrogant red-breasted eastern thrush—the *Robin*—now awaits his cue to appear.

Wherever an Englishman settles he

must have a "robin"—and science be hanged! When he set foot in Massachusetts or Virginia and was met by a bird with a reddish front he just naturally dubbed it robin in fond recollection of the little redbreast or ruddock in the gardens beyond the sea. But what about this recklessly used vocable? A moment's reflection reminds us that it is a Scottish diminutive, or pet name, for Robert, which has been borne by innumerable men ever since Robert the Bruce glorified British history in the fourteenth century. But boys were christened Robin long before the Bruce, notably that famous and popular (albeit somewhat mythical) outlaw, Robin Hood. It is certain that many garden plants have been named after that picturesque freebooter. "We have Robin flowers," the Reverend Henry Friend records, "and Robin's eyes, and poor Robins, as names of flowers chiefly, and herb Robert; but often these flowers are called Robin Hoods." This author gives us, in his "Folklore of Flowers," many further particulars, and expresses the opinion that the English redbreast is called Robin in memory of the romantic hero of Sherwood forest, although the only resemblance between bird and highwayman is that line in one of the old ballads celebrating his adventures thus:

He wente hym full merry synging,
As men have told in tale.

Waxwings could hardly escape their name if they desired to, for they wear a distinctive badge in the "red-sealing-wax" tips of the shafts of wing and tail quills. Two species of the family belong to North America. The lesser and more numerous is the familiar cedar bird or cherry bird, indicating its fondness for the fruits of those two trees, and of many others less conspicuous. The other and larger species is the "northern" or "Bohemian" waxwing, which has a circum-

polar distribution, and rarely comes as far southward as the United States even in midwinter. An odd bit of history is connected with this bird's book-name. Nobody knew until recently where or how it dwelt or nested in summer, and in Europe in former days its irregular appearance in winter caused fear among the superstitious peasantry that it portended evils to follow. Some said that it came from Egypt or perhaps from Turkey; the general opinion likened its invasions to Gypsy wanderings, and Gypsies were thought in those days to be Bohemian. So the bird came to be called Bohemian waxwing. This queer name has followed it to America, where about a century ago the mystery of its sub-Arctic career was revealed by Canadian explorers of the fur-countries.

Vireo is one of the few instances in which a bird's scientific name has become its "common" one. The word is New Latin for greenness, and attempts have been made to popularize it as "greenlet," but they have met with little literary success. We have several species, all plainly labelled. The vireo family is exclusively American and abounds in the western Tropics, where various of its members have received nicknames suggested by their sharply uttered call-notes, such, in Jamaica, for instance, as "johntowhit."

Transference of name from one bird to another is a frequent and confusing accident. *Shrike*, for example, comes from an ancient verb "to shriek," according to Skeat; and William B. Cabot tells us that it is actually called "shrieker" in Labrador; yet, says Professor Newton, the birds that bear it have been so known in English only since about 1840. The name originally belonged in Scandinavia to a local jay, and was applied in England, after the career of the Danes there, to the mistletoe thrush (or storm-cock), still provincially known as the

"screech-bird." H. K. Swan discourses learnedly on this subject in his dictionary of folk-names of British birds. We Americans usually speak of our shrikes as "butcherbirds" because they carry their prey to a tree-crotch or impale it on a thorn, etc., and eat it there at leisure or leave it for another meal—often forgotten. Germans call these birds nine-killers—just why, *Ich weiss nicht!*

To say simply that a warbler is a bird that sings prettily is not definite enough for the present purpose. We mean by it one of the exclusively American family *Mniotiltidae*, the Wood Warblers. Even so the name is not quite good and true, because almost none of these delightful little creatures warble, in any proper use of that verb. My idea of warbling is exhibited in the sweet, chattering song of our house-wren.

It is now my business to tell to what circumstance various wood-warblers owe their common names. Some species owe it to prevailing color, as "caerulean," "bay-breasted," etc.; others to chosen haunts, as in the case of "prairie," "palm" and the like. These need no comment. Several, however, have names that it will be well to explain. "Prothonotary," for example, was settled long ago upon a yellow warbler of the Southern swamp-lands; this is the title of a court officer, and why that early ornithologist Latham applied it to this innocent bird is inscrutable. Swainson's warbler (and hawk) was given as a compliment to another British naturalist who visited America early in the nineteenth century. Bachman's warbler recalls a Charleston physician who assisted Audubon; Lucey's implies a compliment to the daughter of Professor S. F. Baird, and Grace's to a sister of Dr. Elliott Coues—both men famous naturalists of the eighteenth century. In the same way certain warblers were named after Mrs. Blackburn (an English lady), J. K. Townsend, a companion of Nuttall's

western researches, Dr. Kirtland, of Cleveland, Ohio, and in honor of the two celebrated ornithologists, Alexander Wilson (1766-1813) and J. J. Audubon (1780-1851).

The lovely Wilson's warbler of the older books is now listed as "the Canadian" because peculiarly at home there and easily recognized by the necklace of black beads across its golden breast. "Redstart" means red-tailed, from the Anglo-Saxon *steort*, tail. "Summer yellowbird" is a half-forgotten name of the purely lemon-yellow warbler of our gardens, to distinguish it from the black-winged yellow male goldfinch or "wild canary." The yellow-rumped warbler, conspicuous in early autumn, is now generally known as *myrtle-bird*, due to the fact that in winter it feeds in large flocks on the fruit of the bayberry bushes of the southern coast-region, there called myrtle trees; but lately hordes of pugnacious and greedy starlings have despoiled these trees of much of their crop and so persecuted the warblers that the very existence of the yellow-rumps as a species is threatened.

A group of three kinds of warbler-cousins must not be forgotten. These are the *water-thrushes*, a suitable name, for they look like the diminutive thrushes, and are especially fond of woodland water-courses. One of the three species, however, is very numerous everywhere in summer, and listed as "golden-crowned thrush," or more commonly as "oven-bird," because of the domed shape of its nest, made on the ground among thickets. These water-thrushes are the only real singers in the family, and resemble in several particulars the wagtails and pipits of the Old World.

There remains to be considered in this name-tracing search through the roster of American field and forest birds only one section—that of the *Sparrows* and their allies, constituting the cone-billed, seed-eating family *Fringillidae*. Having

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disposed of this extensive but etymologically rather uninteresting group we shall be able to pay attention to the Water Birds.

The general term *Sparrow* is as old as anything in English, and has suffered very little change from its prehistoric form developed from a northern stem, *spar*, that is said to contain the idea of "fluttering activity," so characteristic of these restless hoppers; not all etymologists, however, accept this derivation. Among the North American species of this family few require much explanation of their visiting-cards. The Savannah sparrow was so called by Wilson from its frequenting, as he says, "the low countries on the Atlantic coast from Savannah where I first discovered it." The Georgian river and city were bordered by extensive level meadows, which the Spanish explorers styled "savannas"; in the same way we get "prairie" from the French. The *yellow-winged sparrow* gets its nickname "grasshopper" from its buzzing little song. Our word "chippy" is a mispronunciation of chirper. The *fox sparrow* is chestnut, not foxy red; and the *whitethroat* is more noted for its voice than its color. The *white-throated sparrow* was the "nightingale" of early settlers in Quebec; and in Nova Scotia it has become "Poor-Kennedy-bird," recalling a legend of a certain Kennedy who was lost in the forest and imagined the bird as condoling with him. In New England everybody knows it as "Peabody bird," believing it especially numerous about Peabody Glen in the White Mountains, and many farmers will tell you that in spring it says: "Sow wheat, Peabody, Peabody." Of all the versions of the whitethroat's appealing chant I like best the one prevalent in Ontario, where it seems to sing "Sweet Canada, Canada."

With the first sign of winter storms there appear in the United States from the North small, plump "ground-birds,"

dark slate-color above sharply contrasted with the white of the breast. Every one used to call them simply *snow-birds*; but the somewhat elevated tribe of "bird lovers" have taught us to say *junco* instead—that is the generic name of the species. The change is rather convenient, especially in the northern parts of the bird's specific range, for it separates this winter migrant from the proper white snowbird, or "snowflake," great flocks of which come down with the snow-drifts into Canada, but of which we see few south of the Great Lakes.

Bunting. In the first general books on our avifauna, these snowflakes, the bobolink and some other fringilines were classed as "buntings," a word that hardly exists here. Among them was a familiar pasture-loving sparrow, marked by the white margins of the tail. It used to be cataloged as bay-winged bunting, but Wilson Flagg made a happy change from this to *vesper bird* indicative of its distinctive habit of singing in the evening dusk. The origin of "bunting" is unknown. Wright wrote in his *Lyrick* in the year 1300:

Ich wold Ich were a threstelcok,
A bunting or a lavercock.

Of the many guesses I like best my own, particularly as later I found it supported by the great Oxford Dictionary. Among country people, even now, a short-tailed, stocky chicken is called a "bunt," as it has been from time immemorial. The buntings are notably round and plump as compared with most other small song-birds, and "bunting" or "buntlin," diminutives of bunt, I believe to have been given them in reference to this appearance. How long ago did mothers begin to sing, "Bye, baby bunting, father's gone a-hunting!"

Another group of the Fringillidae contains the finches (German *fink*) of which we have such representatives as the goldfinch, indigo-bird and pine-finch.

The goldfinch is the black-capped yellow-bird, thistle-bird, lettuce-bird or wild canary of our gardens. (The original "canary" by the way, was a greenish and yellow native of the Canaries, Madeira and Azores. Examples were carried from the Canary Islands to Europe in the sixteenth century, and soon became so much in demand as cage-birds that the species was rapidly exterminated in its home.) The pine-finch is often listed as a "linnet." The true linnet is the European "flax-bird" as indicated by its ancient German name for flax, kept in our language in such terms as linen, linseed, etc., and in the Swedish family patronymic Linne, Latinized into Linnæus. Our redpolls are its near cousins. The pine-finch is also known as "siskin," a Norse word for any small songster, and thus a relic of the Danish influence on English speech.

Most of the other members of the Fringillidae family need little or no explanation. Of the names given to our various grosbeaks only one deserves serious attention—that of our wandering winter visitor whose large size and handsome yellow and black plumage makes it particularly noticeable. In the books it is listed as "evening grosbeak" (yellow or western grosbeak would be better), which came about by an odd error. Its first describer, knowing that his new species came from the Columbia River region, intended to label it "western," in Latin *vespertina*; but unfortunately the first person who wrote about the bird in English understood this specific name as meaning "evening," a poetic application of the word more properly used, as already mentioned in our name vesper-sparrow.

The males, at least, of all the North American grosbeaks—the rose-breasted, the blue, the black-headed and the "red-bird"—are dressed in rich colorings. The "redbird," that glory of the southern states, is more widely given the title

of *Cardinal*, for its plumage is just that shade of crimson worn by those high ecclesiastics of the Roman hierarchy that have figured so strikingly in political as well as in religious history. He is rivaled in our woods only by the vivid scarlet and black of the northern tanager.

WATER-BIRDS

It has seemed best, for present purposes, to discard "without prejudice" the most recent scientific arrangement in classification, by which some groups of aquatic birds are intermixed with the terrestrial and arboreal ones; and instead to leave the land birds by themselves. Nevertheless, the succession of the divisions of water birds from lowest to highest in rank will be followed as given in one of the latest manuals, namely, Dr. P. A. Taverner's "Birds of Canada" (Ottawa, 1934). His arrangement requires me to begin with the loons and grebes and end with gulls.

Loon. A vague notion is held by many persons that this name for the great northern divers is somehow connected with "lunatic," because of the wild surroundings in which the bird lives, and its eerie cry; in fact, it is merely a mispronunciation of an Icelandic word still prevalent in the Shetland Islands. Its relatives, the *Grebes*, took their name in French from the crest that adorns the heads of several conspicuous species.

The various birds that get their living out of the ocean, and dwell on its shores include in their names antique forms, frequently unintelligible; many also are the product of vagrant fancies coupled with superstition. Masefield, the sailor-poet, knew them—

Gonys and gullies an' all the birds o' the sea,
"They ain't no birds, not really, said Billy
the Dane.

"Not mollies, nor gullies, nor gonys at all,"
said he,

"But simply the sperrits of mariners living
again."

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Molly, short for "mollemoke" in various forms, is explained by Swann as an old Dutch-mariner's name for the fulmar, now corrupted into molly-mawk and applied to other oceanic species. It is on record since earliest British Arctic voyages, and remains in common use on Greenland waters and in northern Britain.

Of all these winged wanderers none is more mysterious than the *Petrel* to most of us; and a part of the mystery is in its name. Those who know the Pacific Coast variety of Leach's "petrel" might make a strong argument for its nocturnal cry as the name-source, but the voices of other species do not support this view. The traditional explanation is the one adopted by W. H. Hudson in his delightful little book "British Birds." "The name 'petrel,'" he says, "comes about in a very curious way. It is the diminutive of Peter, given to the bird on account of a habit it has, when gliding along just above the surface, of dropping its feet and paddling, producing the idea that it is walking on the water. I am not quite sure that this is a correct derivation; Peter (the apostle), it will be remembered, was not quite successful in his attempt to walk on the waves. Sailors call the petrels 'Mother Carey's chickens,' but not, as might be imagined from such a name, on account of any tender regard or feeling of affection for the birds."

Now who is, or was, this Mother Carey, whose chickens flock on the heaving ocean and play in the wild winds, so that the smaller sorts are dubbed "storm-petrels"? The great black fulmar petrel, which haunts the Cape of all Storms (as Vasco de Gama purposed to christen the tip of South Africa) is known as Mother Carey's goose! There seems to be no generally accepted picture of the lady in the minds of our northern folk or definite knowledge of origin or habitation. Some say she is a sort of

marine witch and that the black little birds are her imps; others smilingly dismiss the matter by telling you that she is an aunt of Davy Jones!

But they know better along the shores or on the waters of the Mediterranean, and will assure you that she is *Mater* or *Madre* or *Madre cara*—Dear Mother (of Jesus), *Sancta Maria*, to whom all southern sailor-men breathe a prayer for safety when the clouds lower on the horizon and the flitting harbingers of gales so mysteriously arrive and cluster about the laboring ship; and French fishermen say the petrels are *oiseaux de Notre Dame*—birds of Our Lady. "Madre cara" might suffer a sea-change in the mouth of an English-speaking sailorman, its Spanish or Italian origin unheard or forgotten; but can you imagine a foremast-hand on a Liverpool limejuicer or a Gloucester fishing-smack breathing a frightened prayer to Mother Carey?

Related to and associated with the petrels are the huge *Fulmar* (origin undetermined), the "gony" of Dutch-seamen at the Cape of Good Hope, and the *Shearwaters*, whose skimming, twisting flight accounts for their name, among many nicknames. Here may as well be mentioned guillemots, puffins and murre, whose queer names are indefinable. *Pelican* is known to everybody, but why or when it came to be so called is still obscure. *Cormorant* is near-Latin for "sea-crow."

This brings us to the *Hérons*, presumed to be so called in imitation of their hoarse cries. Dr. Skeat explains the familiar taunt "not to know a heron from a hand-saw" by reminding us that the diminutive of the French *heron*, *heroneau*, was corrupted long ago in British speech into "heronsewe," this into "hernser" and this family finally mutilated into "hand-saw"; similarly, *heronceanu* became "heronshaw," an heronry. The short form "hern" is now only poetic, as in Tenny-

son's rippling line "I come from haunts of coot and hern." Our white herons are distinguished as egrets (also their exquisite plumes), derived from *heigir*, an old German word for heron. In the same family are the bitterns, storks and ibises. Bittern goes back to early Latin, but what it indicated is obscure; *Ibis* is of Egyptian stock; *Stork* seems to be Scandinavian.

Duck, an old Norse-English word, means diver. The names of few of the North American are in need of explanation. When we say "wild duck" we usually mean *mallard*, a shortening of the French word for a male duck, particularly the drake of this species. *Scoter* is a form of "scooter"; *shoveler* and *scaup* refer to the shape of their bills. *Gadwall*, *Pochard* ("poker") *Teal* and *Wigeon* are of ancient northern lineage. *Eider* is Dutch for fowl, but French Canadians call an eider "moyas," as learned by the first colonists from the Micmac Indians. A section of the duck tribe includes the fishing ducks or saw-bills, goosanders and shieldrakes, under the group-name *Mergansers*—a queer invented combination of *mergus* and *anser* which equals "diving ducks." Sheldrake, locally heard, should be spelled "shieldrake," for it means a bird spotted in such a way as to suggest (at least in Great Britain) armorial markings on a knight's shield. A noisy species has the name *Old Squaw* in humorous reference to its squeals.

Strange to say no American bird north of Mexico officially bears the name it had in any Indian language, with the doubtful of two or three. "Waxy" snow geese (genus *Chen*) are generally known in northern Canada as "wavies," a mispronunciation of the Chipewyan (?) word *wawa*; and gunners about Lake Ontario call the noisy long-tailed duck "cowheen," variously spelled. I find a hint as to the origin of this queer designation in William Kirby's "Annals of Niag-

ara," where the author, speaking of conditions about 1784, remarks: "The Niagara River was in the early spring covered with flocks of millions of that active noisy bird, the kaween, so called by the Algonkin name—the ice-duck or old man, so called. . . . They are now (1870) nearly extinguished in the Niagara River." Perhaps "sora," the little rail, might claim a place here.

Goose and *Swan* are nouns of ancient lineage in northern Europe. Of our wild geese the one best known to the public is the Canada goose or "honker." Several different geese are "brant," to sportsmen, from an old word "brent," burnt or charred. The genus *Branta* includes also the barnacle goose, taking its name from a fabulous belief in the middle ages of which I have given a rather full account in my "Birds of Legend, Fable and Folklore."

Swans, cranes and rails call for no notice here, except possibly in the case of the *Sora* (rail), whose name no doubt was learned from Indians.

Few avian groups are as numerous as that of the shore birds (*Charadrii*), and none presents such a bewildering multiplicity of popular names. The sandpipers, snipes, curlews, plovers, etc., are objects of sport all over the world, and local words and values vary endlessly. Some foreign names have been brought to America, and have been applied more or less accurately to our similar species. Swann's Dictionary of the sporting and folklore names of British birds requires 200 pages of space. From this and broader sources we learn that *Plover* is anglicized French, with the primitive significance of "rain," i.e., a rainy-season bird. The *Dotterel*, one of the plovers, suffers under the imputation of being a "little dolt," because, like the "booby" gannet, "fool-hen" (spruce grouse), and others, it appeared stupid in the presence of danger. Old books give the dotterel this reputation. Kay (1570) relates that

it is taken at night by the light of a candle, when it becomes absorbed in the actions of the fowler, "for if he stretches out an arm the bird also stretches out a wing, if a foot likewise a foot . . . and so, being intent on the man's gestures, it is deceived and covered with the net spread for it." The snipe *Dunlin* might well call itself "brownie." *Godwit* is perhaps "good wight" in the sense of excellent eating—at any rate Ben Jonson refers to it as a delicacy. *Dowitcher* is bad German, indicating belief in its German nativity. *Knot*, the sandpiper, is supposed to have furnished Canute with a favorite dish; hence that stanza in Drayton's "Poly-Olbion":

The knot that called was Canutus bird of old,
Of that great king of Danes, his name that still
doth hold,
His appetite to please, that farre and neare was
sought,
For him (as some have sayd), from Denmark
hither brought.

Certainly it used to be netted in England in great numbers and fattened on bread and milk as a table delicacy.

Those Arctic sea-fowls, the *Auks*, interest us on account of the sadly romantic history of the extinction of the giant of the race, and the large present market value of the shells of the few great auk's eggs still in existence. The word "auk" has often been accounted for by connecting it with the awkward gait of the bird, but evidently it is only a rude pronunciation of the Icelandic name *alka* (whence the family designation, *Alcidae*). While the great auk still existed in northern and western Scotland and Wales, it was called *gare* or *garfowl*, or *gairfowl*, as we read in documents of ancient date; but the origin and meaning of these variously spelled terms remain disputable.

Gull is a bird-name unexplained by etymologists. I am inclined to think that its root might be found somewhere in the wake of such nouns as *gullet*, *gulp*, *et al.* The bird's foolish voracity in seizing and trying to swallow anything that falls in its way without examination accounts for the word "gullibility," to express too easy credibility.

WHAT IS CALCULUS OF VARIATIONS AND WHAT ARE ITS APPLICATIONS?

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THE calculus of variations belongs to those parts of mathematics whose details it is difficult to explain to a non-mathematician. It is possible, however, to explain its main problems and to sketch its principal methods for everybody.

The first human being to solve a problem of calculus of variations seems to have been Queen Dido of Carthage. When she was promised as much land as might lie within the boundaries of a bull's hide, she cut the hide into many thin strips, put them together into one long strip, the ends of which she united, and then she tried to secure as extensive a territory as possible within this boundary. History does not describe the form of the territory she chose, but if she was a good mathematician she covered the territory in the form of a circle, for to-day we know: Of all surfaces bounded by curves of a given length, the circle is the one of largest area. The branch of mathematics which establishes a rigorous proof of this statement is the calculus of variations.

Newton was the first mathematician to publish a result in this field. If a body moves in the air, it meets with a certain resistance, which depends on the shape of the body. The problem Newton studied was, what shape of body would guarantee the least possible resistance? Applications of this problem are obvious. The rifle bullet is designed in such shape as to meet with a minimum resistance in the air. Newton published a correct answer to a special case of this problem, namely, that the surface of the solid considered is obtained by revolving a curve around an axis. But he did not give the proof or the calculations that had led him to the answer. So Newton's solution had no

great effect on the development of mathematics.

A new branch of mathematics started with another problem formulated and studied by the brothers Bernoulli in the seventeenth century. If a small body moves under the influence of gravity along a given curve from one point to another, then the time required naturally depends on the form of the curve. Whether the body moves along a straight line (on an inclined plane) or along a circle makes a difference. Bernoulli's question was: which path takes the shortest time? One might think that the motion along the straight line is the quickest, but already Galileo had noticed that the time required along some curves is less than along a straight line. The brothers Bernoulli determined the form of the curve which takes the shortest possible time. It is a curve which was already well known in geometry for other interesting properties and had been called cycloid.

What is common to all these problems is this: A number is associated with each curve of a certain family of curves. In the first example (that of Queen Dido) the family consists of all closed curves with a given length, and the associated number is the area of the inclosed surface; in the second example (that of Newton) the number is the resistance which a body somehow associated with the curve meets in the air; in the third example (that of the brothers Bernoulli) the family of curves consists of all curves joining two given points, and the number associated with each curve is the time it takes a body to fall along this curve. The problem consists in finding the curve for

which the associated number attains a maximum or a minimum—this is the largest or the smallest possible value; in Dido's example, the maximum area; in Newton's example, the minimum resistance; in Bernoulli's example, the shortest time.

Some problems concerning maxima and minima are studied in differential calculus, taught in college. They may be formulated in the following way: Given a single curve, where is its lowest and where is the highest point? or given a single surface, where are its peaks and where are its pits? With each point of the curve or the surface, there is associated a certain number, namely, the height of the point above a horizontal axis or a horizontal plane. We are looking for those points at which this height is greatest or least. In differential calculus we deal thus with maxima and minima of so-called functions of points, i.e., of numbers associated with points; in calculus of variations, however, with maxima and minima of so-called functions of curves, that is, of numbers associated with curves or of numbers associated with still more complicated geometric entities, like surfaces.

A famous question concerning surfaces is the following problem, the so-called problem of Plateau: if a closed curve in our three-dimensional space is given, we can span into it many different surfaces, all of them bounded by the given curve, e.g., if the given curve is a circle we can span into it a plane circular area or a hemisphere or other surfaces bounded by the circle. Each of these surfaces has an area. Which of all these surfaces has the smallest area? If the given curve lies in a plane, like a circle, then, obviously, the plane surface inscribed has the minimum area. If the given curve, however, does not lie in the plane, like a knotted curve in the three-dimensional space, then the problem of finding the surface of minimal area bounded by the curve is very complicated. The question, which was solved

some years ago by T. Radó (Ohio State University) and in a still more general way by J. Douglas (Massachusetts Institute of Technology), has applications to physics, for if the curve is made of a thin wire and we try to span into it a thin soap film, then this film will assume just the form of the surface of minimum area.

We frequently find that nature acts in such a way as to minimize certain magnitudes. The soap film will take the shape of a surface of smallest area. Light always follows the shortest path, that is, the straight line, and, even when reflected or broken, follows a path which takes a minimum of time. In mechanical systems we find that the movements actually take place in a form which requires less effort in a certain sense than any other possible movement would use. There was a period, about 150 years ago, when physicists believed that the whole of physics might be deduced from certain minimizing principles, subject to calculus of variations, and these principles were interpreted as tendencies—so to say, economical tendencies of nature. Nature seems to follow the tendency of economizing certain magnitudes, of obtaining maximum effects with given means, or to spend minimal means for given effects.

In this century Einstein's general theory of relativity has as one of its basic hypotheses such a minimal principle: that in our space-time world, however complicated its geometry be, light rays and bodies upon which no force acts move along shortest lines.

If we speak of tendencies in nature or of economic principles of nature, then we do so in analogy to our human tendencies and economic principles. A producer most often will adopt a way of production which will require a minimum of cost, compared with other ways of equal results; or which, compared with other methods of equal cost, will promise a maximum return. It is obvious that for this reason the mathematical theory of economics is to a large extent application

of calculus of variations. Such applications have been considered by G. C. Evans (University of California) and in particular by Charles F. Roos (New York City). A simple but interesting example, due to the economist H. Hotelling (Columbia University), is to find the most economic way of production in a mine. We may start with a great output and increase the output later or we may increase the output in time or we may produce with a constant rate of output. Each way of production can be represented by a curve. If we have conjectures concerning the development of the price of the produced metal, then we may associate a number with each of these curves—the possible profit. The problem is to find the way of production which will probably yield the greatest profit.

In the mathematical theory of the maximum and minimum problems in calculus of variations, different methods are employed. The old classical method consists in finding criteria as to whether or not for a given curve the corresponding number assumes a maximum or minimum. In order to find such criteria a considered curve is a little varied, and it is from this method that the name "calculus of variations" for the whole branch of mathematics is derived. The first result of this method, which to-day is represented by G. A. Bliss (University of Chicago) and his school, was the equation of Euler-Lagrange, which states: A curve which minimizes or maximizes the corresponding number must in each of its points have a certain curvature which can be determined for each problem.

Another method consists in finding out quite in general whether or not a given problem is soluble at all. For example, we consider the two following extremely simple problems: two given points may be joined by all possible curves; which of them has the shortest length, and which of them has the greatest length? The first problem is soluble: The straight line segment joining the two points is the

shortest line joining them. The second problem is not soluble: There is no longest curve joining two given points, for no matter how long a curve joining them may be, there is always one which is still longer. The length is a number associated with each curve which for no curve assumes a finite maximum.

This second method of calculus of variations was initiated by the German mathematician Hilbert at the beginning of the century. The Italian mathematician Tonelli found out twenty years ago that the deeper reason for the solubility of the minimum problem concerning the length, that is, for the existence of a shortest line between every two points, is the following property of the length: A curve between two fixed points being given, there are always other curves as near as you please to it, and yet much longer than the given curve (*e.g.*, some zigzag lines near the given curve). But there is no curve very near to the given curve and joining the same two points, which is much shorter than the given curve. This property of the length is called the semi-continuity of the length. Contributions to this Hilbert-Tonelli method are due to E. J. McShane (University of Virginia), L. M. Graves (University of Chicago) and to the author.

Another way of calculus of variations was started in this country. G. D. Birkhoff (Harvard University) was the first to consider so-called minimax problems dealing with "stationary" curves which are minimizing with respect to certain neighboring curves and at the same time maximizing with respect to other curves. While the minimum and maximum problems of calculus of variations correspond to the problem in the ordinary calculus of finding peaks and pits of a surface, the minimax problems correspond to the problem of finding the saddle points of the surface (the passes of a mountain). The simplest example of such a stationary curve is obtained in the following way: if we consider two points of the equator

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of the earth, then their shortest connection on the surface of the earth is the minor arc of the equator between them. There is, as we have seen, no longest curve joining the two points. But there is one curve on the surface of the earth which, though it is neither the shortest nor the longest one, plays a special rôle in some respects, namely, the major arc of the equator between the two points.

One of the greatest advances of calculus of variations in recent times has been the development of a complete and systematic theory of stationary curves due to Marston Morse (Institute of Advanced Study). The most simple example of this theory, which calculates the number of minimizing and maximizing curves as well as of stationary curves, is the following "geographical" theorem quoted by Morse: If we add the number of peaks and the number of pits on the surface of the earth, and subtract the number of passes, then the result will be the number 2, whatever the shape of the mountains may be (highlands excluded).

There are many technical details of calculus of variations which are hardly available to a non-mathematician. They

are the type of theory which frequently leads to the belief that mathematical theories are remote from the urgent problems of the world and useless. Real mathematicians do not worry too much about these reproaches which are engendered by a lack of knowledge of the history of science. Mathematicians study their problems on account of their intrinsic interest, and develop their theories on account of their beauty. History shows that some of these mathematical theories which were developed without any chance of immediate use later on found very important applications. Certainly this is true in the case of calculus of variations: If the cars, the locomotives, the planes, etc., produced to-day are different in form from what they used to be fifteen years ago, then a good deal of this change is due to calculus of variations. For we use streamline form in order to decrease to the minimum possible the resistance of the air in driving. It is through physics that we learn the actual laws of this resistance. But if we wish to discover the form which guarantees the least resistance, then we need calculus of variations.

CHROMIUM

By Professor COLIN G. FINK

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THE old Egyptians and the ancient Chinese five thousand and six thousand years ago were well versed in the art of metals. They fabricated a wide variety of articles both of the general utility type, such as weapons and household necessities, and of the purely art type, such as statues, vases, jewelry, etc. But they were very limited in choice of metals to work with. Six thousand years ago there were only five metals known to man—copper, tin, gold, silver and lead. It was almost two thousand years before

iron was added to the list. To-day we have at our command over seventy metals. The one metal which forms the very basis of our modern civilization is iron. The world to-day produces this metal at the rate of one hundred million tons per year. No other metal can compare in volume, in low cost, and in valuable mechanical properties. The next metal, as far as world's production is concerned, is copper, with an annual world's output of two million tons, that is, only two pounds of copper for every

one hundred pounds of iron produced. The output of any of the other metals is less than that of copper.

The supply of lead and copper is alarmingly limited in comparison with that of iron. At the present rate of consumption we would exhaust our lead and copper mines in less than one hundred years.

Iron builds our bridges and skyscrapers, subways and steamships, railroads and automobiles and machinery in general—besides millions of small articles ranging from the farmer's scythe to the woman's needle. There are a number of fortunate circumstances that give iron this domineering position in our modern industrial structure: First of all, the supply of iron in the earth's crust is almost limitless; secondly, the methods of converting iron ore into useful steel are relatively cheap; thirdly, the mechanical properties of the various iron products are superior to those of other metals.

Yet with all the outstanding advantages of iron—its low cost, its strength and its vast supply—it has one very serious weakness: It does not withstand weather conditions in those localities where it is most needed. The more dense the population of any area the more rapidly will iron rust or corrode.

Exhaustive investigations carried out in the foremost laboratories all over the world, seeking to find the best method or means of counteracting the corrosion of iron and its economic waste of \$3,000,000,000 a year, finally led to a solution—the addition of another metal to iron. This metal is chromium. Chromium added to iron makes it rustless, stainless. It is less than a generation ago that our civilization received one of the greatest gifts of all times from the metallurgical laboratories—stainless steel.

Why, you might inquire, was the discovery of stainless steel of such recent date? Although chromium has been known to the metallurgist since 1797, it

was not possible to produce stainless steel before the advent of electricity and the electric furnace, which furnished the necessary high temperatures impossible of attainment with wood- or coal- or oil-fired furnaces.

The metal chromium was discovered by a French chemist, Vauquelin, in 1797, and since various chemical compounds of the metal were beautifully colored—orange, yellow, blue, green, etc.—he called the new metal chromium from the Greek word *chroma*, color. The emerald owes its green color to chromium, the ruby its red and the sapphire its rich blue color. Chrome green is the best and most permanent green pigment we possess.

Whereas it is comparatively simple to obtain tin or lead or copper from its ores, the recovery of chromium in a relatively pure state is much more difficult, and on this account over a hundred years elapsed, after Vauquelin's discovery, before the metal entered the commercial field.

It was not until the arrival of the electric furnace about thirty years ago that the problem of making chromium metal and chromium alloys was commercially solved. Hundreds of important chromium alloys are made electrically to-day: Without these chromium alloys the modern automobile would be impossible. Our food, oil, paper and other chemical industries are very much dependent upon chromium steels. Chromium alloys for airplane parts that resist corrosion, for armor plate that defies the best piercing shells, for high-speed tools that turn out thousands of products as against dozens with the old steel tools without chromium, for the heater wire that toasts your bread at breakfast and the knife that cuts the bread, the best ball bearings, the Zephyr of the Burlington Railway and the Flying Yankee that rushes you from Boston to Bangor are built entirely out of chrome steels.

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is the so-called 18/8, that is, 18 per cent. chromium, 8 per cent. nickel and the balance chiefly iron. Over half of the chrome steels produced to-day are of this 18/8 type. And these are the steels that interest the architect in particular. The Chrysler Building and the Empire State Building have consumed many, many tons of this bright, shiny, rust-defying alloy of chromium. It is as strong and tough as the best of the older steels made without chromium. The rapid spread of the application of this stainless steel or 18/8 alloy in the modern building has been most phenomenal: Store and window fronts, massive entrance doors and grill work, interior arch trim, ceiling and corridor trim, lighting fixtures, staircases, guard rails, step plates, escutcheons, door plates, elevator doors, window fittings and many more.

Stainless steel is easily workable—can be drawn, spun, machined and welded. The most complicated architectural designs are faithfully carried out. The metal has an attractive permanent luster. All maintenance expense, such as for painting ordinary steel, which runs into thousands of dollars, is entirely eliminated. More than 100,000 square feet of polished stainless steel trim cover the exterior of the Empire State Building that will never need painting.

The higher the chromium content of the alloys the more resistant to corrosion. Accordingly, the question might arise: "Why use chromium alloys, why not chromium metal itself?" The answer to that is that we have not yet learned how to produce chromium metal as cheaply as iron, nor have we yet learned how to produce malleable sheets of chromium metal, although the metal is inherently ductile. We have met the situation in one way:

We have learned how to apply a surface of pure chromium on iron, steel, brass and other metals: In other words, we can electroplate pure chromium metal on iron and in that way protect the iron from corrosion. You are all too familiar with chrome plate, so we need say very little. It may interest you to know that we can chromium-plate aluminum and zinc-die-cast metal. And we can color chrome plate—"chromed chrome," so to speak. The life of printing plates, chromium plated, has been extended a million fold due to the extreme hardness of chromium. The fine needles that knit the sheer hosiery of our ladies are chromium plated to prevent any rust spots. Automobile jewelry, bathroom fixtures and numerous other articles are regularly chromium plated to-day. Chromium plate is better than nickel or zinc plate, because it is more resistant to both wear and corrosion. And it will not tarnish or react with sulfur, as does silver. Accordingly, the molds for rubber tires and other rubber goods are made of chromium-plated steel.

The quality of the plate will decide the life of the chromium-plated article. You can not estimate the thickness and quality of chromium plate by mere visual inspection. Accordingly, it is important to have your chromium plating done by a reliable concern that will apply the proper thickness of plate free from flaws.

In conclusion, may we emphasize the very important rôle the metal chromium is playing in the new post-war civilization: Due to its outstanding properties of corrosion- and wear-resistance it has made a vast number of products and processes, structures and speeds possible—some of which were not even dreamed of a few years ago.

SURVEYING THE BUTTERFLIES OF VIRGINIA

By AUSTIN H. CLARK

CURATOR OF THE DIVISION OF ECHINODERMS, U. S. NATIONAL MUSEUM

OVER one hundred years ago Drury, Cramer and Boissudal and LeConte mentioned, more or less incidentally, quite a number of butterflies as occurring in Virginia. Since their time only a few scattered notices of butterflies from that state have appeared in print. So, as I live in Washington, am too young for golf, too old for tennis and too lazy for hunting, it occurred to me that it might be worth while to undertake a detailed survey of Virginian butterflies.

It may be of interest to explain briefly how I am going about the job of making a survey of the butterflies of Virginia. The equipment consists of Henrietta, a very ancient though still more or less reliable Ford, nets, jars, etc., paper, pencils and a wife to operate the pencils. As I drive along all the butterflies seen are noted and recorded by the wife. From a car moving not too rapidly—and Henrietta can't move too rapidly—it is possible to distinguish all the larger butterflies, swallowtails, pierids, the larger nymphalids and others. Every once in a while I stop and look for the smaller field-inhabiting species along the roadside or for the wood-loving species in the woods. Bogs, marshes and other likely places engage my more serious attention.

Gardens are always well worth visiting. The technique of examining a garden is simple. You send the wife up to ask the proprietor if you may have the pleasure of admiring the lovely flowers. He or she always says "Yes." Then, with the trusty paper, pencil and wife, you praise his or her skill in making flowers grow, at the same time murmuring apologetically and enviously about the sad results you have had in trying to coax flowers from the ground in a city back yard with a soil composed of frag-

ments of bricks in a matrix of sterile blue clay. By following this method you can get in half an hour a complete list of all the commoner flower-frequenting butterflies in the neighborhood without raising any horrid suspicions as to your sanity.

Whenever I stop, Henrietta's radiator always engages my attention. You have no idea what a good little bug-catcher Henrietta is. The bees and wasps come in and circulate mainly about the passengers on the back seat. But the butterflies stick to the radiator. Once in Georgia Henrietta succeeded in catching a species I never caught with my net.

This reminds me that if you are to make a really accurate survey of the butterflies of any area under modern conditions you must develop a sort of instinctive corpse-consciousness. As an illustration of what I mean, not long ago one of my friends in Washington brought in a butterfly new to the fauna of the District of Columbia that he had picked up on Constitution Avenue. It was a specimen of *Danaus berenice*. Holland gives the habitat of this species as southern Texas, Arizona and southern New Mexico. But if you keep your eyes open you will soon learn that it is common in Florida and ranges northward to southern North Carolina. I was loath to sadden my friend, but the frayed remnant of a New England conscience asserted itself, and I told him his specimen had undoubtedly dropped off the radiator of a car from Florida.

Certain species are more easily found as caterpillars than as adults. This is especially true of the little dark brown pigweed skipper, *Pholisora catullus*, and the turtle-head butterfly, *Euphydryas phaëton*. So pigweed is always examined for the shelters of this little

skipper, and the turtle-head, *Chelone glabra*, is always gone over carefully for the webs of the social caterpillars of the turtle-head butterfly.

By taking road records in this manner it is surprising how much territory one can cover. All the accumulated information is useful in determining general distribution, relative density of population in various regions and time of appearance in different sections of the state.

I have visited all the one hundred counties of Virginia, most of them several or many times. I try to time my successive visits to each county so as to be there at different seasons in successive summers. From now on my work will be more or less concentrated in certain strategic areas, particularly the coastal plain, the mountains, and isolated swamps, marshes and bogs.

Geographically, Virginia seems to have been a somewhat indefinite concept in the minds of a number of eminent lepidopterists. So we find listed as from Virginia butterflies whose place of origin was the Virgin Islands, Virginia in southern Brazil, Virginia City, Nevada, and West Virginia. A Philippine species is mentioned from Virginia through having been originally described, by error, from West Virginia.

The bursting of these geographical bubbles leaves us with a substantial body of 132 species and subspecies definitely known from the State of Virginia, of which I have taken personally 125. There are also 132 species known from New York State. But there is an important difference between the number recorded from New York and the number recorded from Virginia. From New York we know practically all the species that should occur there, together with a few that have no business there, while no less than twenty-five species occur both north and south of Virginia but have not as yet been taken within its borders, or else occur in its immediate vicinity, as for instance at Cabin John,

Maryland, on the north bank of the Potomac, where *Incisalia henrici* and *Atrytone bimacula*, unknown from Virginia, have been found. Four species credited to Virginia, undoubtedly correctly, have not been found in the state within the past one hundred years. I am willing to bet that they will not succeed in eluding me much longer. Have I any takers?

Virginia is divided into four faunal areas. First, there is the Canadian zone represented by more or less isolated islands on the high mountain tops in the southwest. The one characteristic butterfly here is a dark southern form of the green comma, *Polygonia faunus smythi*. It is a pleasure in midsummer to hunt for this butterfly along the roads through the cool red spruce or lashorn forests at 5,000 feet and then in the evening write post-cards to your friends in Washington telling them you are looking forward to getting down into the lowlands where you can get warm again.

The mountain country in the western part of Virginia belongs to the Transition zone. Characteristic of this zone within the state are *Argynnis aphrodite*, *A. bellona*, *A. myrina* (which is very local), *Euphydryas phaëton*, *Polygonia progne*, *Glaucopsyche lygdamus* (which is by no means so rare as it is supposed to be), *Incisalia augustinus*, *Pyrgus centaureae* and a few others. You can find all these except *Argynnis myrina*, an inhabitant of wet grass lands, along the Skyline Drive.

A few words regarding *Pyrgus centaureae* may not be out of place. This little gray and white skipper has a most deplorably unethical concept of its zoogeographical responsibilities. It occurs in the mountains of Scandinavia and of central Asia, and in North America is found in the Hudsonian zone in Labrador, British Columbia, the high mountains of Colorado and elsewhere. It is found in the Canadian zone in Quebec and in the Transition zone, intruding into the Upper Austral, from New Jersey

to North Carolina. It is absent from New England, and has been recorded only from the extreme north and the extreme south of New York. Can you imagine any living thing so callous toward culture and so scornful of industrial initiative and energy as almost ostentatiously to omit from its range New England and New York? In one respect, however, this little butterfly is quite consistent. No matter where it lives it always flies in the same temperature. So in Norway and in Labrador you see it flitting about in midsummer, in Virginia only in early spring.

In Virginia the Upper Austral zone occupies a rather narrow strip along the eastern foothills of the mountains and enters the southern part of the Shenandoah Valley. So far as butterflies are concerned it is a zoogeographic myth. Perhaps *Phyciodes nycteis* belongs to it, but if it does its one idea seems to be to escape from it, for most of the records are from the Transition or Canadian zones.

Approximately the eastern half of the state belongs to the Lower Austral zone. This is an extraordinarily interesting region, and when you are in it you yourself often become an object of intense and practical interest to its numerous anthropophagous arthropodous inhabitants. For on a very hot day in the great coastal swamps you deliquesce into a sort of stew greatly appreciated by dipterous demons of many sorts and also, I may add, by certain butterflies.

It is unfortunate that the butterflies have not as yet learned their responsibilities in regard to the Lower Austral zone. Their contemptuous disregard for the excellent work of the Biological Survey is as disconcerting as it is unethical.

In the Canadian and Transition zones the majority of the butterflies you see, especially in late summer, are not strictly confined to those zones; but although their distribution is not strictly coterminous

with the life zones, it falls within more or less definite limits.

In the Lower Austral zone the sit-downers appear. These sit-downers are species, usually from the Transition zone, that occur in localized areas far from their normal, or perhaps I should say orthodox, habitat.

Most spectacular of these sit-downers is that finest and most magnificent of all the fritillaries, *Argynnis diana*, the great desideratum of all amateur collectors and the great joy of the get-rich-quick type of entomological dealer.

Argynnis diana was described by Pieter Cramer from Virginia in 1779. It was next reported from Virginia 116 years later, this time from Blacksburg in the mountains. Nineteen years later Professor Ellison A. Smyth, Jr., wrote that he had found it in Montgomery, Washington and Giles Counties, all in the mountains. I have personal records of this species from nineteen additional localities, from Bath County southwestward and as far east as Bedford and Patrick Counties. I thought I had put this insect in its proper place as an inhabitant, in Virginia, of the Transition zone, occurring chiefly at considerable altitudes.

Imagine my consternation, therefore, when my young friend, Mr. Carroll M. Williams, of Richmond, produced specimens last summer from Zuni and New Bohemia on the Blackwater River in the heart of the coastal plain. When my mind began to recover from the shock—the idea of beautiful *diana* living in those awful coastal swamps would be a shock to any one—a new light began to dawn upon me. It became clear how Cramer was able to secure the specimen he described and figured 158 years ago. His collector probably captured it in the swamps of the thickly settled coastal plain.

Furthermore, other things became clear. I had been much astonished to find *Satyroides eurydice*, so character-

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istic of grassy bogs in New England and Canada, in a swamp on the Meherrin River near Emporia, and *Argynnis cybele* at Zuni, at almost the same spot where Mr. Williams took *diana*. This last, perhaps, is not so strange, for *cybele* is very active, and I have a record from Northampton County on the Eastern Shore. But I had found *Satyroides eurydice* previously in Virginia only just across the Potomac from Washington in Arlington and Fairfax Counties, and at Burkes Garden in Tazewell County in the southwestern mountains.

Quite as strange is the wholly unorthodox behavior of the two forms of the swamp skipper *Atrytone dion*. Two years ago I captured thirty-six specimens of this in the Dahl Swamp in Accomac County. These represented the dark southern form called *alabamiae*, known previously from one male and two females from near Mobile, Alabama. Last summer I caught some more in the boggy hollows among the sand dunes just west of Cape Henry. But these represented the northern brightly colored form, not the dark southern form I had captured in the Dahl Swamp further north. Specimens from North Carolina also represent the northern, not the southern, form.

There is a simple explanation for the occurrence of Transition zone butterflies in localized regions in the coastal plain. The western border of the Dismal Swamp and the swamps of the Blackwater, Nottoway and Meherrin Rivers are fed by cold ground water that oozes from the porous soil. The same is true of the boggy hollows near Cape Henry. In these regions occur all sorts of anomalous plants.

The cold soil from which the cold ground water oozes provides for low-feeding caterpillars that hide away in the daytime on or near the ground, like the caterpillars of the fritillaries, satyrids and swamp skippers, conditions more or less comparable to those of the Transition zone, in spite of the aerial Hades three

or four feet higher. It is the environment of the larvae and of the pupae that determine the occurrence of a butterfly. As for the adults, the more Hades-like the atmosphere the more they seem to like it. So it is really not so anomalous as it would appear at first sight to find Transition butterflies in the heart of the Lower Austral zone.

Two butterflies are especially characteristic of this region. One of these is a small skipper, *Amblyscirtes carolina*, found elsewhere only in similar localities in North Carolina. The other is a rather large satyrid, *Enodia creola*, known elsewhere from single examples from North Carolina, Michigan and Texas, two from Chicago, three from Opelousas, Louisiana, and four or five from near Athens, Georgia.

The case of *Enodia creola* is especially interesting. The genus *Enodia* (or *Lethe*) includes about 180 species and subspecies living in southeastern and southern Asia and western China, four fifths of them in the Himalayas, and in addition two species living in eastern North America. *Enodia creola* belongs to a small section of the genus, the subgenus *Kerrata* of Moore, in which the males are characterized by having the fore wings more or less elongate and bearing a band of shaggy androconia. The females have no distinguishing features. In addition to *creola* this group includes three species living in western China and Sikkim. All four are regarded as rare. The late Dr. William Barnes had a standing order with dealers to send him any specimens of *creola* that might come into their hands, but was never able to secure one. So far as I know, no specimen of *creola* has ever come into the hands of any dealer.

A year ago I found *creola* along the western border of the Dismal Swamp and brought back seven specimens, one male and six females, the female having been previously unknown, or at least undescribed. I doubled the number of

specimens in the National Museum collection. I thought I had done rather a handsome thing. Did I get any thanks for my pains? No! It seems that, having found this species common, I should have suspended all other activities and specialized on gathering up all I could.

Last summer I brought back seventeen from near Suffolk and near Zuni. In addition to those I captured, Dr. G. W. Rawson, of Detroit, Mr. Williams, of Richmond, and W. Herbert Wagner, a high-school student of Washington, found it near Petersburg, near New Bohemia, at Zuni and near Emporia, all on the Blackwater or Meherrin Rivers. In the localized areas in which it occurs in eastern Virginia it is occasional or frequent, and in some spots near Suffolk even rather common.

Enodia creola almost always flies with *E. portlandia*, the type species of the genus *Enodia*. This also has generally been regarded as a rare insect. Two years ago I found it in abundance at Virginia Beach and secured sixty specimens, about half of which were good enough for the National Museum collection. Since then I have found it at many localities in the coastal plain, its range in Virginia being much more extensive than that of *E. creola*, which is not found east of the western border of the Dismal Swamp. I have learned that wherever I see cane (*Arundinaria gigantea*) growing in wet woods I am practically certain to find *portlandia*.

This species was described by Fabricius in 1781 from a specimen in the John Pattison Yeats collection in London. At that time many butterflies from Virginia had reached England, partly in response to advertisements inserted by Drury and others in the local papers. It is quite possible that eastern Virginia is really the type locality for *portlandia*; it seems to be more common here than anywhere else, and the name *portlandia* certainly suggests the Duchess of Portland, who at that time had a very fine collection of American butterflies. She was the wife

of that Duke of Portland, prime minister of England, whose claim to a permanent place in history rests upon his affable and exquisitely courteous stupidity.

The rarity of these two species of *Enodia* in collections is due in part, at least, to a marked disinclination on the part of lepidopterists to getting their feet wet—to go sloshing through mud in more or less dense undergrowth. Many lepidopterists, I have noticed, also hesitate to face the music emanating from hordes of determined mosquitoes with a baritone element provided by huge menacing tabanids.

Both of our species of *Enodia* are unique among Virginian butterflies in being normally more or less crepuscular, flying about until it is too dark to see them. But they also fly by day, usually in the shade. Their Asiatic relatives are mainly crepuscular.

Enodia creola and *Argynnis diana* offer great temptations to speculators, both financial and intellectual. Scorning financial speculation, as I have no specimens of either, let us indulge in a bit of scientific contemplation.

If I were a botanist and *Enodia creola* were a plant I would see nothing strange in the distribution of the group to which it belongs, for several genera of plants are confined to western China and the southern Appalachians. Furthermore, if I were a botanist I would say that it is a type that once inhabited the Appalachian region—before that region got its back up, so to speak. As the mountains rose the types peculiar to that area retreated both east and west into the lowlands, so that now we find *creola* localized in the swamps of the coastal plain and also occurring at widely separated stations in the Mississippi valley.

This reasoning would make *creola* older than the mountains of Virginia and would indicate that it inhabited the mountain region before the mountains were there at all. Speaking as temporarily an incipient botanist I am inclined to believe that, on the analogy of the

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associated plants, this is true. But reverting to my normal status as a zoologist I refuse to commit myself.

Argynnis diana is even more interesting. It is the only truly Appalachian butterfly. It ranges from Bath County, Virginia, to Florida, east almost to tide-water, and west to Illinois and Arkansas. But it is of regular occurrence only in the mountains, where it is local and generally not common. It appears to be most numerous in Transylvania County in southern North Carolina and in more or less nearby regions. It is difficult to work out its distribution accurately, since most specimens in collections were secured from dealers who judiciously failed to provide them with locality labels.

The local distribution of this fritillary is quite anomalous—for a butterfly. On White Top Mountain I found it consorting with *Polygonia faunus smythi* in the Canadian zone. Mostly it keeps to the Transition zone, slinking through the undergrowth in steep damp valleys or on steep damp mountain sides. It is also recorded from the Upper and the Lower Austral zones.

Unlike *Enodia creola*, *Argynnis diana* has no close Old World relatives. What are its relatives? If you watch a male *diana* carefully you will notice that it has pretty much the same habits as a female *cybele*. In fact, it is not at all difficult to mistake a male *diana* as it zigzags through the undergrowth for a female *cybele*. You commonly detect your error just as it passes out of reach and begins to "step on the gas."

The male *cybele* is more adventurous than the female—more given to exploring open country and less to flitting through undergrowth. The female *cybele* and the male *diana* have about the same ideas on these subjects, though as a rule *diana* flies higher than *cybele*. The female *diana* is scarcely adventurous at all, keeping mainly to the woods. Frequently she comes out of the woods, flies a short distance along the roadside, then enters the woods again.

Male *dianas* frequently show on the black areas on the wings the characteristic argynnid markings, faintly traceable in deeper black. These are usually more evident in the females. Do these markings furnish any clue to *diana's* relatives?

Look between the two lowest veins on the fore wings for a black spot or mark half way between the body and the oblique bar somewhat more than half way to the outer edge of the wing. There is none. Among all our fritillaries the only ones in which the space between the two lowest veins from the body to the oblique bar has no dark mark are *cybele*, *leto*, *nokomis*, *nitocris*, *coerulescens*, *diana*—and *idalia*, which last is quite different. In all these the shingle-like arrangement of the scales of the fore wings in the males is interrupted over the large veins by a band of androconia. In all the sexes are more or less different in color. The sexes of *coerulescens*, from the mountains of Chihuahua and southern Arizona, approach those of *diana* above, the male being heavily suffused with dark brown, which more or less obliterates the markings, and the female being dark bluish, also heavily suffused.

If *diana* is regarded as a member of this group, with which it undoubtedly belongs—the absence of the spot between the two lowest veins of the fore wings is much more important than it would appear at first sight—much of the mystery in regard to it disappears. It is true that it is an extreme form of the group in which nature seems to have tried to obliterate the normal fascies of a fritillary by an overdose of cosmetics; but the same thing has happened to a somewhat lesser extent on the upper surface, though not on the lower, of *coerulescens*.

If we can consider *diana* as most closely related to *coerulescens*, it would represent a type from the highlands of Mexico localized in the southern Appalachians, corresponding exactly to the small form of the gold-banded skipper, *Rhabdoides cellus*, found locally in the Virginia mountains.

Just what the food plant of *diana* is has never been accurately determined. Of course one suspects violets. It has been raised on violets. But if it feeds normally on violets, why has it not extended its range northward? *Cybele*, a violet feeder, which always occurs with it, ranges far northward. I can not help feeling that we have much yet to learn about this fine butterfly.

So far I have mentioned only home-loving permanent residents of Virginia. In addition to these permanent inhabitants, the justly famed hospitality of the state attracts in the summer many rhopalocerous as well as human tourists. Chief among these summer visitors is the rather large clear yellow pierid, *Phoebis eubule*, known in parts of the South as the "traveling butterfly."

So far as I have been able to ascertain, this insect does not overwinter in Virginia, being killed off in all stages in the winter. It appears in early summer coming up the coast and up Chesapeake Bay, and also filtering in through the mountains in the southwest from the Mississippi valley. By the end of the summer it has become common, or at least frequent, over the greater part of the state, being especially numerous along the sea coast and in the west.

In certain regions it is usually observed dashing along in one definite direction with a determined and purposeful air. In other regions it seems to fly indiscriminately in any direction. The same thing has been noticed in various other places in the South. It seems to be imbued with a frantic desire to get away from some regions as fast as possible, something after the fashion of a cockroach on a hot stove. In other regions it just dashes wildly about. You see it doing this at Big Meadows on the Skyline Drive in late summer. If one is entomologically inclined and wishes to lose a few pounds I can not imagine a better or more effective method of accomplishing this end than by trying to catch this species here.

Another summer visitor to Virginia is

the Gulf fritillary, *Dione vanillae*. This comes up the coast region and is sometimes common about Norfolk. Still another is *Ascia monuste*, the southern cabbage white, also known only from the coastal region.

The salt marshes along our eastern coast support two species of butterflies found nowhere else. Both are skippers, one *Panoquina panoquin*, brown, the other, *Poanes aaroni*, chiefly bright yellow. The little brown chap is common or abundant in all the salt marshes, and especially numerous on the Eastern Shore and about Lynnhaven. I have found it as far north as Mathews County. The yellow one so far has eluded me, but Mr. Frank Morton Jones has recorded it from Chincoteague Island and has sent me records from other places.

In order to catch these salt marsh skippers you must first locate patches of flowers—sea-lavender or sea-oxeye. If there are any of these skippers anywhere about they will be found on these flowers. It is almost hopeless to try to catch them over a broad amorphous expanse of salt marsh without flowers, for you do not see them until they suddenly jump up and almost instantly seem to dematerialize into thin air. I may add that unless you are still addicted to that joyful amusement of all children, paddling about in muddy water, you will search for these skippers only when the tide is out.

Many of the butterflies of Virginia have only a single brood a year. This brood may appear only in early spring, as in the case of the little brown hair-streak *Incisalia augustinus*, *Pyrgus centaureae*, *Hesperia metea*, *Atrytonopsis hianna*, etc.; it may appear in early summer, as with *Euphydryas phaëton*; it may appear in midsummer, as with *Strymon titus mopsus*; or it may not appear until the end of the season, as in the case of *Hesperia leonardus*.

The large fritillaries—*Argynnis diana*, *A. cybele* and *A. aphrodite*—are supposed all to be single brooded, but the single

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brood emerges from early summer until almost the end of the season. The same is the case with *Cercyonis alope*, which flies from about the first of July onward; but in this species the males are relatively short lived and disappear while the females are still numerous.

One-brooded butterflies are nice little boys—and girls—to deal with. They mostly stick closely at home. You don't get zoogeographical jitters in trying to explain their basic distribution. It is true that they are frequently so localized that they are difficult to find, but when you do find them they are almost always common in their home territory. The species that fly only in very early spring are sometimes rather rare in collections, largely because of the disinclination of many lepidopterists to face the chilly breezes of that season.

Most of the one-brooded butterflies appear all at once and fly for only three or four weeks. They are nice conservative models for other butterflies to follow. They are very satisfactory to deal with, for in them variation is, as a rule, reduced to a minimum. The fritillaries have a somewhat disconcerting way of varying from early summer, when they first appear, to autumn. These variations have been studied only in the case of *Argynnis cybele*.

A number of butterflies have one full brood in spring or early summer and a partial brood, or broods, sometimes represented by very few individuals, in summer. This is true especially of certain skippers, as for instance the silver-spotted skipper and a number of its relatives, and of some satyrids, as *Satyrodes eurydice*. In these species the caterpillars from the eggs laid by the adults of the first brood form pupae, most of which remain as pupae until the following spring; but from a few the butterflies emerge later in the season. In most of our swallowtails and not infrequently in our pierids some of the pupae of each brood remain dormant until the following spring, the second brood being therefore not quite com-

plete. In butterflies with a partial second brood the individuals of this brood usually resemble those of the first, though they may differ more or less from them.

Many Virginian butterflies have two broods. In one case, that of the little orange-tip, *Anthocharis genutia*, as it occurs at Blacksburg, the second brood immediately follows the first and the species entirely disappears in early summer. In most cases the first brood appears in spring and the second in summer. This is the case with all the swallowtails except *Papilio marcellus*, which has three or more broods, with all the angle-wings except *Polygonia faunus smythi*, which is single-brooded, and with various other species.

No butterfly could be expected to overlook an opportunity like this for disconcerting the lepidopterist. So we find that in two-brooded species the individuals of the two broods almost invariably differ more or less markedly, those of the second brood being usually larger, darker and with shorter wings than those of the first. It would not be so bad if rhopalocerous irresponsibility stopped here. But it goes further. The angle-wings, which live over winter as adults, all emerge in autumn under essentially similar conditions. The individuals one sees in the spring, therefore, are usually pretty much all alike. In the case of the swallowtails, however, the emergence of the spring brood from the overwintering pupae covers a considerable period of time and a wide range of conditions.

In most of the species the earliest individuals of the spring brood are much smaller than those that appear later, and sometimes differ rather widely from them. Thus in certain years the earliest examples of the blue swallowtail or "silk-butterfly," *Papilio philenor*, as found at Leesburg and probably elsewhere, lack the tails, and the metallic green on the under side of the hind wings is restricted in extent. These tail-less blue swallowtails scarcely differ from the form called *acauda* from the hot lands of Mexico, and

if their origin were unknown would certainly be referred to it. Other individuals in early spring have the hair on the body so long that they look moldy, and also have a row of conspicuous white spots on the upper surface of the wings. These may be referred to the form *hirsuta*, the prevailing form in northern California. The children of these, and indeed their own brothers and sisters that emerge later, are much larger—the common type of eastern blue swallowtail.

The very small yellow swallowtails, *Papilio glaucus*, that you see in the woods in early spring are quite different from those you see in late spring and in summer. They have a pre-nasal tuft of long whiskers on the frons and long hair on the body, and are colored like the form called *canadensis*, which flies in the far north. You will find that *canadensis* is given as the northern subspecies of the typical *glaucus* of the South. But if you go strictly on the basis of specimens and keys you can not separate early spring individuals taken in Virginia in certain years from *canadensis*. In the South only the males of this form occur, so far as is known. The larger females, which emerge later, are more like the summer form. If you go on the basis of specimens and keys only, disregarding locality labels, you will inevitably reach the conclusion that *canadensis* occurs in both sexes in the far north where the species is single brooded, but in Virginia is found only in early spring and in the male sex only. If *canadensis* is to be regarded as a valid subspecies it must be considered as parthenogenetic in the South, where only one sex occurs. As I am not as yet converted to the idea of any parthenogenetic animal occurring in the male sex only, I prefer to regard *canadensis* as a variety rather than as a subspecies of *glaucus*.

It may be mentioned that in the case of two-brooded butterflies the habits of the individuals of the two broods are usually more or less different. In the

swallowtails the individuals of the spring brood keep to the woods, or to the borders of the woods, and are very active, as if their small size imbued them with an inferiority complex urging them to cover as much territory as possible. The larger individuals of the summer brood are lazier and more indolent, and bolder, ranging far over open country. In the case of the angle-wings, however, it is the long-winged light-colored form that wanders, the short-winged dark summer individuals staying pretty much at home.

The numerous butterflies with three or four broods offer additional difficulties. For usually the spring brood is more or less localized, the successive summer broods spreading over wider and wider territory. As in the case of two-brooded species, the first brood may have two or more very different forms, as is well seen in the common blue, *Lycaenopsis argiolus pseudargiolus*, and the checkered white, *Pieris protodice*. The worst feature of the situation is that so many of the butterflies with several broods are skippers, and skippers are so small that they often pass unnoticed unless they are rather numerous.

There are various skippers in Virginia that are recorded only in the summer or autumn. Whether these come in from the South each year, or whether they are permanent inhabitants overlooked earlier in the season on account of their small size, scarcity and general inconspicuousness, has not been determined.

Two of the several-brooded Virginia butterflies have a very wide distribution, being found practically all over the northern hemisphere. These are the common blue, *Lycaenopsis argiolus*, and the small copper, *Lycaena phlaeas*; the latter ranges as far north as land extends. In both of these the early spring individuals resemble those from further north, where there is only a single brood, though not necessarily those from the most northerly portions of their ranges.

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butterflies with several broods you do not notice until the end of the season in late September or October, and ordinarily not then unless the season is rather dry. If conditions happen to be just right the wretched things again appear in the spring form, though without any infuscation. Fortunately most lepidopterists have become tired of collecting butterflies when October comes around, so none of these late forms have received names.

In the winter they go still further. In the case of *Colias eurytheme* the upper surface becomes very light, the under side dark green; the hind wings become elongated, and the brown circle in the center of the under side is extended outward in a long triangle. In this camouflage individuals look for all the world like some strange Arctic species. All three forms of *eurytheme* are modified in the same way. The white females are particularly puzzling, as they have a way of becoming greenish above.

The common little tessellated skipper, *Pyrgus communis*, in the winter loses all the brownish on the under side of the hind wings, becoming black and white. You would scarcely guess what it was if you did not know it could not be anything else.

One of the interesting things in regard to Virginia butterflies is the way the same species differs in size in different areas. For instance, *Cercyonis alope* is small and dark in the mountains—the form *maritima*. In the piedmont it is larger and not so dark—the form *alope*. Near the sea in southern Princess Anne County it becomes very large—the form *pegala*. It is easy to remember the distribution of one of these forms. Just bear in mind that when it comes to *Cercyonis alope* in Virginia *maritima* means farthest from the sea. Perhaps I should add that in the western mountain meadows this butterfly frequently suffers from a sort of systematic lunacy. The yellow on the fore wings may be replaced by white, or

it may become very dark, and all sorts of inexplicable variations occur.

A number of other butterflies are small in the mountains, becoming larger as you approach the sea. But just the reverse is the case with the common blue. In the mountains you find extraordinarily large individuals, while the smallest are those from near the sea coast.

In studying the butterflies of any region there is one thing you have to look out for. In many species the relative proportion of the sexes varies widely in different localities. The males as a rule wander more widely than the females. In the swallowtails, for instance, the females generally tend to keep near the woods, while the males scatter all about. On the muddy banks of streams you often see many butterflies sucking up moisture. These are usually all males. It is very seldom that you find bibulous ladies among our butterflies.

Some species, of course, are always ready to upset the nicest generalizations. Thus the pretty little skipper, *Poanes zabulon*, is unorthodox in that the males are the ones that stay at home, being found chiefly along the sides of streams through the woods. The females prefer the more abundant life, wandering widely over open fields where the males seldom or never venture.

There is much of interest yet to be learned about our butterflies if you regard them as living things and not as nature's artistic triumphs to be impaled on pins with unnaturally extended wings.

To me, at least, it is much more satisfying to wave an insect net than a golf stick or a tennis racquet. I get quite as much exercise in the long run. Then there is always the gamble; you never can tell when you will get something really worth while. And when you have captured something really worth while, why, there it is in your collection. That is why you hear much about fish stories, but nothing about butterfly stories.

INAPPARENT VIRUS DISEASES¹

By Dr. E. V. COWDRY

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WE naturally think of virus diseases as exemplified by those we have heard most about. The epidemic of encephalitis, which struck St. Louis in the late summer of 1933, was certainly not neglected by the newspapers. The pandemic of influenza in 1918 was unforgettable. Infantile paralysis is a virus scourge which, we have reason to believe, is more devastating in the United States than in other parts of the world. There are many others—yellow fever, smallpox, common cold and so on. These virus diseases compel us to do something through fear of death or disfigurement, but the good resolutions made in time of epidemic soon pass away and research is sadly handicapped by lack of funds.

Another group of virus diseases affects domestic animals. Hog cholera, rinderpest and foot and mouth disease are typical. The motive to overcome them is to save dollars, and they were brought under control promptly.

No class of vertebrates escapes. Among the invertebrates many viruses operate, especially in insects.

In plants, as in domestic animals, the economic loss stimulates research so that much attention is given to the virus diseases of tobacco, potatoes and sugar cane. Over a thousand species and varieties of plants are known to be subject to these diseases,² and the number steadily increases.

Even the lowly bacteria are not exempt. They are destroyed by special viruses called bacteriophages.

¹ Aided by an appropriation from a grant by the Rockefeller Foundation to Washington University for research in science.

² M. T. Cook, *SCIENTIFIC MONTHLY*, Feb., 1937, 174-177.

Viruses constitute a hazard for all classes of living things from the highest to the lowest. Fortunately some species, perhaps genera, and possibly orders are not so afflicted, and for any given susceptible species the mortality is seldom 100 per cent. and the chances for infection may be small; otherwise, life would be extinguished wholesale.

It is interesting to note that virus diseases grade from extremely dangerous to seemingly harmless conditions. Persons bitten by mad dogs, who are untreated and contract rabies, invariably die. But this 100 per cent. mortality is extremely rare in human virus diseases, though it is the rule in some lower forms. In yellow fever, smallpox, encephalitis and many severe virus diseases some of the afflicted individuals usually recover.

There are other virus diseases which are seldom if ever fatal in uncomplicated cases, as for instance, herpes, common colds and warts.

A true conception of the action of any virus involves a consideration of the mild cases of disease which it provokes as well as of the serious ones. Both are equally part of the picture. Take infantile paralysis. In times of epidemic only a very small percentage of the population is affected, almost wholly children and very rarely mature individuals. The explanation is that in cities many children and at least 80 per cent. of adults have had mild, undetected attacks which produce immunity. In rural districts the percentage is a little lower. The precise number can not be calculated, owing to the expense of making immunity tests, but perhaps only one in five or ten thousand cases of poliomyelitis is sufficiently

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severe to be recognized as infantile paralysis. Certainly in an overwhelming majority of instances the disease passes unnoticed. Why a few cases should flare up with such tragic results is an enticing problem.

Recent investigations show that other dreaded virus diseases are ordinarily unrecognized and only exceptionally produce dangerous infections, notably yellow fever among natives hundreds of miles inland from the West coast of Africa, where formerly it was thought to be altogether absent.

Very significant is the fact that some viruses seem invariably to act without exhibiting any clinical symptoms at all. The persons or animals involved remain entirely healthy. These are the *inapparent viruses*.

We may well ask: How can viruses, which produce no noticeable symptoms, be detected?

Until so many were encountered that investigators looked purposefully for them, they were discovered only by accident. Thus, Rivers and Tillett³ injected blood from cases of chickenpox into the testicles of rabbits in an attempt to isolate a virus. After a suitable interval, they removed the testicles, ground them up in physiological saline and injected the material into the testicles of a second rabbit. Several passages from animal to animal were made in this way on the theory that any virus present in the original blood and not showing on the first transfer would increase in amount or virulence. And a virus did appear capable of producing distinctive lesions and nuclear inclusions in the skin and cornea as well as in the rabbit testicles. But Rivers and Tillett proved that the virus was not that of chickenpox. Instead, it was an inapparent virus of rabbits strengthened by passage.

³ T. H. Rivers and W. S. Tillett, *Jour. Exp. Med.*, 38: 673-690, 1923.

Consequently, in attempts to pass pathogenic viruses, great care is now taken to make sure that an inapparent virus is not awakened from a condition approaching dormancy in symptomless animals which look normal.

Very tragic consequences have brought to light another inapparent virus. Some years ago the King of Greece was bitten by a pet monkey and died in a mysterious way. One of my assistants, Dr. B., while working in New York was also bitten by an apparently healthy *Macacus rhesus* monkey. He died of paralysis. A hitherto unknown virus was isolated from his spinal cord which is easily maintained in rabbits which it kills.^{3a}

Again, by chance, Jackson⁴ observed bodies in the submaxillary glands of guinea pigs which she thought were protozoa. It was found, however, by Cole and Kuttner⁵ that they were duct cells modified by virus action. Discovery of this "salivary virus" pointed the way to the recognition of a whole series of inapparent viruses. Cells similarly altered in the salivary glands of mice, rats and small Chinese rodents, called "Hamsters," served as clues. In addition the salivary glands of some human infants, *Cebus fatuellus* monkeys and moles show comparable alterations strongly suggestive of virus action, which action has, however, not been demonstrated experimentally.

A conspicuous feature of the modification is the formation of inclusions within the nuclei. Fig. 1 illustrates the inclusion laden cells in two sections of the submaxillary gland of *Cebus fatuellus*. In the one on the right a very much enlarged duct cell is shown. It is binucleated. The upper nucleus is cut

^{3a} A. B. Sabin and A. M. Wright, *Jour. Exp. Med.*, 59, 115-136, 1934.

⁴ L. J. Jackson, *Jour. Infect. Dis.*, 26: 347-350, 1920.

⁵ R. Cole and A. G. Kuttner, *Jour. Exp. Med.*, 44: 855-873, 1926.

about through the center and exhibits a centrally placed nuclear inclusion, which appears dark gray in the photograph but which, in the original preparation, was stained pink with eosin. Since eosin is classed as an acid dye, the inclusion is said to be "acidophilic." It is seen to be surrounded by a clear halo, and most of the basophilic chromatin (in black) is displaced toward the nuclear membrane. Only a slice from the side of the lower nucleus is included in the section. The limits of the cytoplasm are easily distinguished and within it certain cytoplasmic inclusions in the form of roughly spherical dark gray masses of unequal size.

In the section on the left, a single-nucleated, enlarged duct cell is seen. Its nucleus is hypertrophied and exhibits a similar centrally located acidophilic nuclear inclusion surrounded by a clear halo, with chromatin and nucleolus tending to marginate on the nuclear membrane. A few hazy cytoplasmic inclusions are visible.

It is to be noted that in both single cells are affected and the neighboring duct cells show no signs of injury.

The problem is enlarged by the discovery of nuclear inclusions, unassociated with recognizable disease in various other parts of the body and particularly in the kidneys. Indeed, it is difficult to mention any species of laboratory animal, whose tissues have been repeatedly examined, which does not occasionally show nuclear inclusions in some tissue or other, even though it is only in a very small percentage of individuals. The probability that such nuclear inclusions are expressions of virus action decreases in proportion as their properties depart, either from those in the guinea pig's submaxillary or from those caused by the hepatic virus which can be regarded as standard types.

Whether a given species, subject to the occurrence of nuclear inclusions in sev-

eral organs, harbors more than one inapparent virus remains to be determined. After the salivary glands, the kidneys most commonly exhibit the inclusions, sometimes in species (*Macacus rhesus*) which do not show them in the salivary glands, while there are instances of species (moles and *Cebus fatuellus*) which have them in the salivary glands and not in the kidneys. Only successful attempts to pass the hypothetical viruses will ultimately settle the question as to their number and relations in each species.

One difficulty is that all viruses of this group, thus far isolated, are species specific. That is to say, they will take only in animals of the same species so young that their mild natural susceptibility has not been converted into resistance by naturally acquired inapparent infections by the virus. The difficulty of working with humans, *Cebus fatuellus* monkeys, moles and hamsters is clear.

How long do these inapparent viruses persist in animals which show no signs of disease?

The age of guinea pigs naturally invaded by the salivary virus is about one month. That adult guinea pigs, which possess nuclear inclusions, contain virus is proved by intracerebral inoculation of animals less than one month old.

Nobody appears to have taken the trouble to purposefully infect the submaxillaries of a series of young guinea pigs, to keep them for years and to test for the persistence of virus. It is likely, however, that some adult guinea pigs, from which active virus has been obtained, were rather more than a year old. A conservative estimate, therefore, places the possible length of persistence of guinea pig salivary virus at one year. It is unlikely that persistence merely results from reinfections, because in adult guinea pigs, and other animals, the inclusion-laden cells have attained a maximum development. Inclusions of vari-

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able size suggestive of active formation are conspicuous by their absence.

In *Cebus fatuellus* monkeys salivary gland inclusions have only been reported in adults. The age of these adults was estimated at three years.⁶ The time of invasion is problematical; but, if these inclusions were produced by a virus operating like all other salivary viruses do in extreme youth, the persistence of virus may have been for, say, two years.

By what mechanisms do these inapparent viruses persist when other pathogenic nuclear inclusion forming viruses disappear?

It is logical to assume that the persistence is associated with the retention of nuclear inclusion containing cells; whereas such cells in herpes or smallpox go on to complete necrosis, are removed and the respective viruses can no longer be found.

When the inclusions reach a stage of maximum development, at which they may remain for months, the respective cells are apparently dead. Evidence for death is not all that might be desired. It is not feasible to test their oxygen consumption, if any. But Pearson⁷ has found that they have lost all mitochondria, which certainly indicates death. The same investigator observed that, when transplants of submaxillaries were made into the peritoneal cavity, the inclusion containing cells remained without change in striking contrast to the neighboring epithelial cells which promptly underwent autolysis. Perhaps the inclusion-laden cells did not change because they were already dead. They may bear, not a charmed life, but a charmed death!

A few cells in this curious state are cast off into the duct and eliminated in

⁶ E. V. Cowdry and Gordon H. Scott, *Am. Jour. Path.*, 11: 647-657, 1935a; *ibid.*, 11: 659-668, 1935b; *Arch. Path.*, 22: 1-23, 1936.

⁷ E. F. Pearson, *Am. Jour. Path.*, 6: 261-274, 1930.

the salivary secretion. This may be the means of natural spread of the virus. But many cells remain for long periods. The death changes in them are halted, and they are not attacked by leucocytes. Their neighbors may be affected but often appear in every respect normal and uninfluenced by their presence.

It looks as if we are dealing with attachment of potentially active virus to dead cells, despite the fact that these duct cells are washed by large volumes of water which pass through the epithelial walls of the ducts to dilute and carry away the secretion of the acinous cells.

The situation in the kidney is equally interesting. We have alluded to the small percentage of adult *Macacus rhesus* and of rats which exhibits greatly enlarged renal cells charged with inclusions both nuclear and cytoplasmic indistinguishable from those in the salivary glands. Such cells are illustrated in Fig. 2. Note the centrally placed inclusions surrounded by clear halos. In these particular sections, the cytoplasmic inclusions are less marked. The neighboring cells exhibit no signs whatever of nuclear inclusion formation. Here again the nuclear inclusions are at a maximum, the cells look dead, a few are desquamated and may pass out in the urine as infective material, but some remain and are immune to the usual forces of disintegration. In the convoluted tubules, where they ordinarily occur, they are, as in the salivary glands, washed in water, though the water passes inward, in the process of resorption and concentration of urine, not outward.

Are any of these inapparent viruses ever dangerous?

When monkeys are given fairly large doses of viosterol the number of them which show the above-mentioned renal nuclear inclusions seems to be increased. In 125 untreated monkeys they were ob-

served in 21, or in 16.8 per cent. In 16 treated monkeys, on the other hand, they were detected in 12, or in 75 per cent., and they were often accompanied by signs of injury. Perhaps the dosage kindled an inapparent virus, but proof is lacking.

Some cases of meningitis are caused by a virus identical with an inapparent virus discovered in seemingly healthy mice by Findlay, Alcock and Stern.⁸

In the lungs of 18 out of 40 cases of whooping cough McCordock and Smith⁹ have found nuclear inclusions resembling those of the salivary glands. They were absent in all but 2 of 90 routine autopsies. Perhaps whooping cough is caused by an awakened hitherto inapparent salivary gland virus acting in cooperation with the Bordet-Genou bacillus or the *Bacillus bronchisepticus*.

Several instances are on record of two pathogenic viruses operating in a single individual at the same time. When this happens, infection by one of them may be unusually severe. Thus, in a child, not yet recovered from the mumps, rabies virus spread to the central nervous system from a small bite on a finger with unprecedented speed and so irresistibly that Pasteur treatment was unavailing, whereas others not having mumps and much more extensively bitten by the same dog, treated in the same way, all survived. (Dr. D. L. Harris, personal communication.)

The converse also holds but perhaps less frequently. One virus may decrease the severity of attack by another. Monkeys suffering from experimental inoculations of dog distemper virus were more resistant to poliomyelitis (infantile paralysis) virus than normal monkeys. The usual poliomyelitis mortality was

indeed reduced for them from 100 to 33 per cent.¹⁰

It is possible, therefore, that inapparent viruses, which probably lurk in bodies of some of us and of many animals unnoticed, may similarly gear up or reduce the virulence of easily recognized, superimposed pathogenic viruses. If this is found to actually happen it may contribute one factor in the as yet unexplained difference in individual susceptibility to virus diseases. It may explain, for instance, why a few persons die or are maimed for life by an attack of infantile paralysis which the vast majority survive without even showing any symptoms of the disease.

What is the probable extent of distribution of inapparent viruses?

Obviously they are not limited to the particular group of salivary viruses. Other nuclear inclusions are encountered by chance in animals which appear to be quite healthy. The inclusions in the livers of dogs are a case in point. They resemble closely inclusions found by Green and his associates¹¹ in foxes. That inapparent viruses occur, which do not even lead to nuclear inclusion formation, is evident. Virus III of rabbits exists without forming inclusions until its virulence is stepped up, or until its amount is increased.

Viruses that form nuclear inclusions are only a small fraction of the total. Many pathogenic viruses produce cytoplasmic inclusions and others no inclusions at all. It is likely that cytoplasmic inclusions will also serve as clues to inapparent viruses and that still other inapparent viruses, which produce no inclusions of either sort and few if any

¹⁰ G. Dalldorf, M. Douglass and H. E. Robinson, *Science*, 85: 184, 1937.

¹¹ R. G. Green, M. S. Kalter, J. E. Schillinger and K. B. Hanson, *Am. Jour. Hyg.*, 18: 462-481, 1933.

⁸ G. M. Findlay, N. S. Alcock and Ruby O. Stern, *Lancet*, pp. 650-654, March 21, 1936.

⁹ H. A. McCordock and Margaret G. Smith, *Am. Jour. Dis. Child.*, 47: 771-779, 1934.

symptoms, will eventually be encountered. At present we must entertain the possibility, even probability, of their presence in all species of mammals. It is premature to speak about other vertebrates, the tissues of which we examine only rarely.

From numerous references in the literature, it is clear that these viruses are widely distributed geographically. But a world survey is very much needed, particularly of the salivary viruses, which will include districts remote from the lines of travel. Are such inapparent viruses found in the animal inhabitants of the tropical jungles along the Amazon and in the forests along the MacKenzie River in the far north? Expeditions, financed by museums, might well provide material from the animals collected.

We know that the mouse virus exists on both sides of the Atlantic and the rat virus on both sides of the Pacific. Specimens from the salivary glands of children in remote parts of the world contain nuclear inclusions, like those from St. Louis children, and so on. Members of a given species, wherever they may be, are generally involved though perhaps in a small percentage of individuals. But there are exceptions. Certain colonies of guinea pigs, for instance, are devoid of inclusions. It may be that their ancestors were removed from exposure to infection in their early youth.

Is there any way of estimating the age of inapparent viruses?

It is generally assumed that a virus, which is found wherever animals susceptible to it occur throughout the world, has been active in the particular species affected for a considerable time, in other words, that the spread has been time-consuming. This argument, however, must be partly discounted for animals which move actively from place to place and which may quickly spread the virus

they carry over wide areas. Humans and domestic animals are the greatest travelers.

Conversely, a virus, active in a restricted geographic area, despite the fact that the members of a susceptible species are widely distributed in many parts of the world, is often regarded as of more recent origin particularly if it is pathogenic (i.e., poorly adapted to its host).

The myxomatosis virus of rabbits and the encephalomyelitis virus of horses (which differs from the Borna virus) are instructive in this connection. Findlay¹² has pointed out that both afflict only rabbits and horses of the New World, although rabbits and horses elsewhere are equally susceptible. Since these two animal species have entered the Americas in historic times, he suggests that the myxomatosis and encephalomyelitis viruses are recent invaders.

Reckoned on the basis of extent of distribution, the salivary gland viruses have been operating for many years. The degree of adaptation of each to a single species of host, and to a definite tissue in that host, was probably achieved slowly. Whether the time is to be measured in hundreds or in thousands of years is pure speculation. To consider evidence on the antiquity of parasites is a natural step in trying to date the viruses which may themselves be parasites.

Metcalf¹³ refers to opalinid protozoa of the genus *Zelleriella* as of "comparatively modern" origin, probably in the early or middle tertiary. This genus made its debut in Leptodactylid frogs of South America sometime between 18 and 54 million years ago, if we follow Gregory¹⁴ in his estimation of geological time. The frogs, with this parasite,

¹² G. M. Findlay and others, *op. cit.*

¹³ M. M. Metcalf, *Am. Naturalist*, 57: 385-411, 1923.

¹⁴ W. K. Gregory, "Cowdry's Human Biology," pp. 53-90. New York: Paul B. Hoeber, Inc., 1930.

immigrated into Central and North America in the Pliocene, say about 7,000,000 B.C. At present frogs of this kind are only found in the Americas and on the other side of the Pacific, in Australia. In both locations they carry *Zelleriellas* in their intestines, which may even be identical as to species. Metcalf suggests that the frogs with these parasitic protozoa, which by now are rather well adapted to them, migrated from South America to Australia by a land bridge long since sunk beneath the waves.

"Are some viruses equally modern?" is a question that we may never be able to answer, but it is possible. However this may be, adaptation of the salivary viruses is not yet complete. When, in a natural infection, the virus first invades the salivary glands of guinea pigs, there is a slight tissue reaction indicative of injury. But it has become so acclimatized to the salivary glands that, in this situation, it never kills, and clinical symptoms have never been reported though they may occur. When, however, the virus is introduced into the brains of young guinea pigs death ensues.

We wonder whether nature holds, for our discovery some day, viruses which by the same slow, inexorable adaptation have gone farther and have attained complete adjustment to their hosts. Perhaps such complete adaptation would be inconsistent with continued propagation of virus. All known viruses cause the death and disintegration of some host cells. If the cells were not injured sufficiently to cause them to go to pieces, virus might remain locked up in them and fail to reproduce itself by spread to other cells, invasion and multiplication in them.

With some other forms of life, adaptation leads to an association which is mutually beneficial. There is no reason to think that viruses ever enter into this sort of partnership with their hosts, but it is conceivable that they do so.

What are the viruses?

The main and cogent reason why most people believe that the viruses, both inapparent and pathogenic, are living organisms is that they, like some bacteria and protozoa, are transmissible from host to host and that in each host they increase in number or multiply. That the viruses are particulate has been demonstrated. The particles of most of them are from 0.1 to 0.01 micron in diameter—that is to say, the diameter of virus particles is so small that from 250,000 to 2,500,000 of them placed side by side in series would extend a distance of only one inch.

It has been repeatedly claimed that viruses constitute hitherto unrecognized forms of life of evolutionary significance which are transitional stages from non-living to living material. This seductive idea is unwarranted; for, since they prey upon living cells and can only multiply, or increase in number, in association with living cells, they are dependent on them and can not be looked upon as having antedated them in the evolution of living beings.

Green¹⁵ sees in the adaptation of free living forms to a parasitic existence clues to the nature of viruses. Tapeworms in the intestinal tract, for instance, have food supplied to them by their hosts and lose the ability to seek and capture it for themselves. They do not need to see, hear, smell or equilibrate, so that sense organs are lost or are not developed. A digestive system is unnecessary. Except for ability to hold tight and multiply there is a reduction of parts. He regards the viruses as organisms (sporozoa), which, in adaptation to a sheltered intracellular existence, have likewise lost parts no longer necessary. In fact, he thinks that they have lost cytoplasm and nucleus, indeed everything except the fundamental structural

¹⁵ R. G. Green, *Science*, 82: 443-445, 1935.

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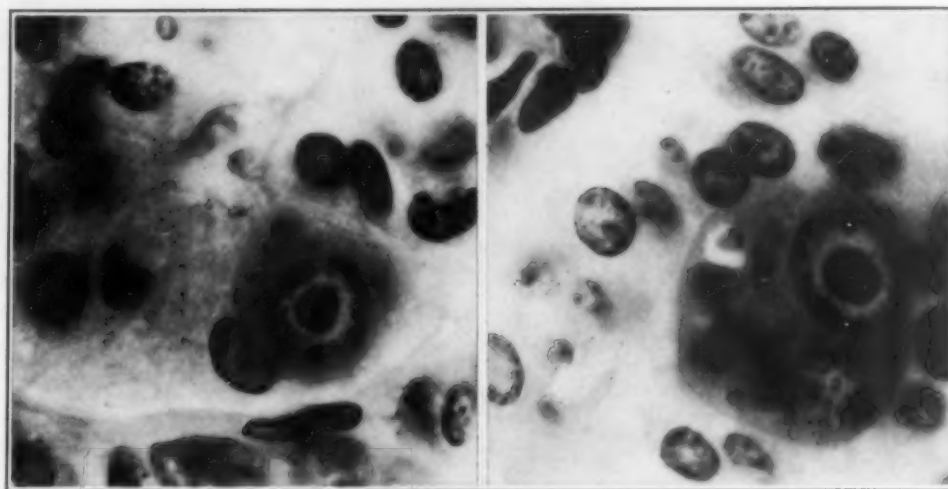


FIG. 1. PHOTOMICROGRAPHS OF SECTIONS OF SUBMAXILLARY GLANDS OF MONKEY (*Cebus fatuellus*). ON RIGHT IS REPRESENTED A MUCH ENLARGED BINUCLEATED DUCT CELL. ONLY THE UPPER OF THE TWO NUCLEI IS CUT THROUGH ITS GREATEST DIAMETER. THIS SHOWS A LARGE, DENSE, DEEPLY STAINED, OVAL NUCLEAR INCLUSION SURROUNDED BY A CLEAR HALO. ON THE LEFT IS ANOTHER ENLARGED DUCT CELL POSSESSED OF A SINGLE NUCLEUS CONTAINING A NUCLEAR INCLUSION SURROUNDED BY A HALO.

organization necessary for multiplication. When cells containing them are ruptured, they escape as living things reduced to the smallest possible size capable of persistence under certain conditions, but not of multiplication unless they gain entry into cells which afford precisely the right kind of nourishment.

This is an attractive conception, extremely difficult to prove or disprove. The anaplasma, found in red blood cells and associated with devastating diseases of cattle, as the name implies, may be viruses without cytoplasm,¹⁶ having lost it in the process of adaptation to intracellular life; but they afford only feeble support to the theory.

Several etiological agents, formerly thought to be viruses, have been found to be organisms which flourish within cells and are called Rickettsias after Howard Taylor Ricketts, who died from infection by one of them. These

Rickettsias are almost at the limit of microscopic visibility, so that some reduction in size may have been effected owing to dependence upon the host cells and loss of unrequired parts.

If the original virus organisms were lowly plants (bacteria or moulds) is it likely this reduction of parts would have occurred? We can not answer, but we can point to the symbionts of the arachnids and especially of the ticks.¹⁷ These are very perfectly adapted to their arachnid hosts. They even inhabit the eggs and are transmitted hereditarily from generation to generation. This has probably been going on for a long time. Yet they are fairly robust microorganisms, easily visible with oil immersion lenses, and none of them have, as far as we can ascertain, been reduced to tiny clumps of reproductive molecules.

The similarity, recently emphasized by Gowen and Price,¹⁸ between viruses and

¹⁶ E. V. Cowdry and C. W. Rees, *Am. Jour. Hyg.*, 21: 94-100, 1935.

¹⁷ E. V. Cowdry, *Jour. Exp. Med.*, 41: 817-830, 1925.

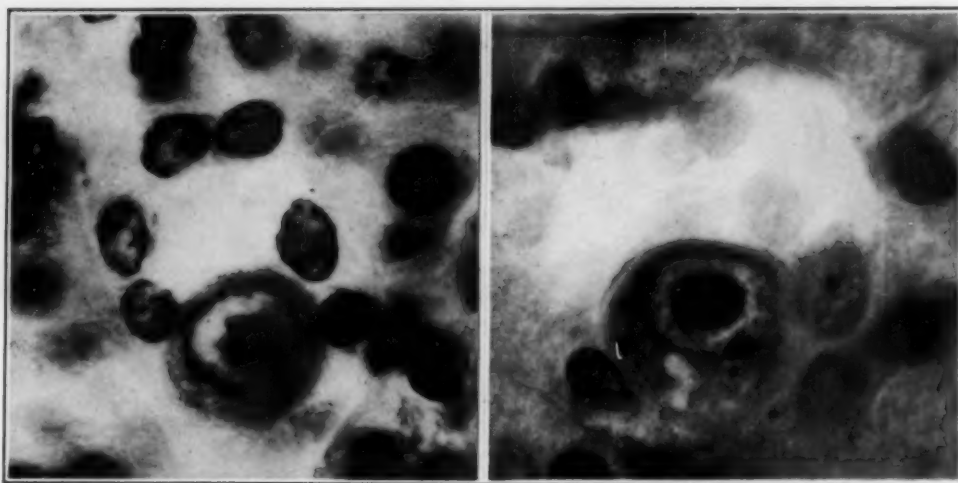


FIG. 2. PHOTOMICROGRAPHS OF SECTIONS OF KIDNEYS OF MONKEYS (*Macacus rhesus*). IN BOTH SINGLE HYPERTROPHIED CELLS ARE SHOWN WHICH EXHIBIT NUCLEAR INCLUSIONS LIMITED BY CLEAR HALOS.

genes is not inconsistent with Green's theory. They are of about the same size, incapable of multiplication outside living cells and produce variegation or mottling in plants. Both mutate under natural conditions, and the resulting new forms perpetuate themselves. Both are inactivated by x-ray and ultra-violet light.

Viruses, however, differ from genes in movement from cell to cell and ability to cause disease in healthy plants. To assume that viruses are detached genes is unwise for many reasons. To do so is obviously inconsistent with the unsupported but popular idea, already mentioned, that viruses constitute steps between non-living materials and the earliest, most primitive organisms. Since the genes develop within cells they can not have been formed before the said cells originated. Consequently, in this view also, viruses, as liberated genes, must have followed, not preceded, the evolution of cells.

The purification and crystallization of

plant mosaic viruses has been taken as evidence that these particular viruses, at least, are non-living. Vinson was the pioneer in this field.¹⁹ In an editorial the *Journal* of the American Medical Association (99: 656, 1934) refers to his work and says that successful crystallization of mosaic virus "... may be regarded by future medical historians as one of the most important advances in infectious theory since the work of Lister and Pasteur." The purification has been confirmed and greatly extended by Stanley.²⁰ The same journal has emphasized, in another editorial, the importance of Stanley's studies.

It is true that when removed from the cells in the process of purification the one feature which stamps mosaic viruses as living, namely, ability to multiply, is lost. They may be then in fact inanimate, as ability to withstand crystallization, solution and recrystallization seems to show.

¹⁹ C. G. Vinson and A. W. Petre, *Contrib. from Boyce Thompson Institute*, 3: 131-145, 1931.

¹⁸ J. W. Gowen and W. C. Price, *Science*, 84: 536-537, Dec. 11, 1936.

²⁰ W. M. Stanley, *Science*, 81: 644-645, 1935.

In susceptible cells, however, it may be a different story, for in them favorable conditions for nutrition and multiplication are afforded, as they are for a great many other viruses, which appear equally dead when separated from cells.

Viruses constitute a large and heterogeneous group. That some will be found to be tiny microorganisms is likely. Others may be organisms, reduced in size in adaptation by loss of unrequired parts, as Green suggests. Still others may not be organismal at all. It is possible that these are chemical substances occasionally originating in consequence of vital activities, which, when once formed, continue to produce more of themselves, if they are given suitable living material on which they can work, as autocatalytic enzymes.

This mechanism of virus formation, if it ever operates, does so only on extremely rare occasions. Viruses change, but no virus has yet been found to originate *de novo* from non-viral material. From an ancestral pox virus many different pox viruses may have developed. A virus originating in one animal may

spread to many others of the same and different species.

The chance of the formation of viruses at rare intervals may be a kind of hazard, or risk which nature runs as chemical and physical forces are harnessed in the evolution of life on earth. Human beings are subject to a greater variety of virus diseases than are any other animals. Many viruses spread to us from lower forms, but some may have originated in our remote ancestors. Consider the female sex hormone, theelin. Here a risk is balanced against a gain. The production of this substance has facilitated the differentiation of higher forms and of man. The hazard which nature has run to achieve this result is that theelin is a dangerous substance closely related chemically, and also in its action, both to an essential vitamin (D) and to substances that can cause cancer. The *Journal of the American Medical Association* has an editorial on cancer as a virus disease. Medical science is advancing, and unexpected light is being shed on many problems in which the viruses occupy a central place.



A REMNANT OF VIRGIN FOREST IN CENTRAL NEW ENGLAND

owned by the Harvard Forest and situated in the town of Winchester, N. H. Due to location within a zone of overlapping of the northern forest and central hardwood forest virgin stands of the region contained a great variety of species, including beech, hard maple, paper birch, ash, hickory, oak and chestnut, together with pine, hemlock and spruce. A knowledge of natural associations of trees, undisturbed by man, is of the utmost importance to the sound development of the art of silviculture as applied to existing volunteer stands or to plantations.

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THE PROGRESS OF SCIENCE

THE MARIA MOORS CABOT FOUNDATION FOR BOTANICAL RESEARCH AT HARVARD UNIVERSITY

THIS foundation was established at Harvard University in June, through the munificence of Dr. Godfrey L. Cabot, of Boston. It is named in honor of Dr. Cabot's wife, the initial endowment being \$615,773,000. The income from this endowment is to be used in a long-range research program for increasing the production of cellulose and other plant products by plant-breeding, especially tree-breeding, and by the improvement of forest soils. For fifty years the income is restricted to the special purposes above indicated, but all restrictions are removed after that period and the income may then be used for any purpose by the university. Because of the interest of the donor in designating the foundation as one for botanical research

it is only reasonable to suppose that the income will be used indefinitely within the general field of botany.

Harvard University administers eight separately endowed botanical institutions, these being, in the order of their establishment, the Botanic Garden, the Gray Herbarium, the Bussey Institution, the Arnold Arboretum, the Botanical Museum, the Harvard Forest, the Farlow Reference Library and Herbarium of Cryptogamic Botany and the Atkins Institution of the Arnold Arboretum. Four of these are located in Cambridge, two in Jamaica Plain, one at Petersham, Mass., and one at Soledad, Cienfuegos, Cuba. The newly established Cabot Foundation fortunately does not involve the establishment of another institution,



STUDENTS AT THE HARVARD FOREST READING INSTRUMENTS

in a field experiment designed to show the influence of different kinds of forest cover, in this case "old field" white pine, on frost depth, soil temperature, water-holding capacity, rate of snow melting and other factors which govern run-off in the early spring, when floods are most likely to occur. Similar stations were located under a nearby stand of mixed hardwoods and in an open mowing.



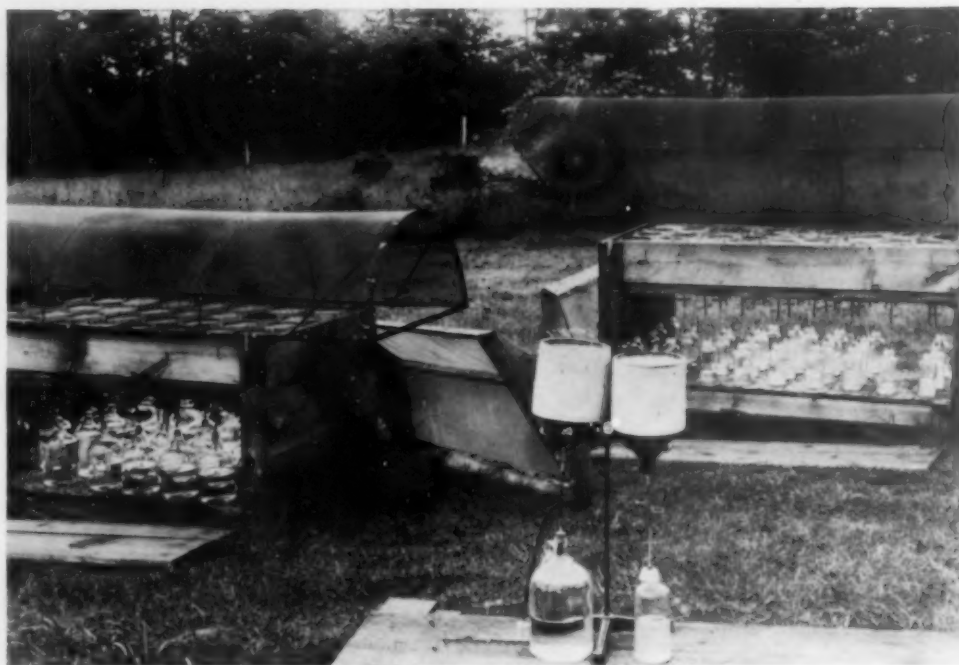
A "TRENCHED PLOT" FOR THE STUDY OF SOIL FACTORS

which affect natural reproduction in a stand of white pine and hemlock. By cutting off the tree roots entering the plot a luxuriant development of herbaceous plants and tree seedlings results, because of changed biotic relations in the soil. There is involved a delicately balanced equilibrium between soil organisms with highly complicated relations. How cultural treatments of stand affect this equilibrium is intensively studied in the field and laboratory.



A NEW GENERATION OF WHITE PINE AND HEMLOCK

resulting from the shelterwood method of natural reproduction, in which the new stand is started under the "shelter" of old. So-called preparatory and seed cuttings open up the canopy of the overwood and create conditions favorable for the establishment and early growth of the seedlings. Finally the old stand is completely removed and the new generation fully freed. This method is applied to even-aged stands and gives rise to successive stands of the same form.



EQUIPMENT USED IN THE STUDY OF THE EARLY DEVELOPMENT OF TREE SEEDLINGS UNDER MEASURED ENVIRONMENTAL CONDITIONS

Studies using this equipment have shown that Scotch and Corsican pines grow more vigorously than does white pine with equal increases in nitrogen supplies. High nitrogen supplies are necessary for utilization of high radiation intensities. At low radiation intensities soil fertility is without influence. The unique symbiotic habit of mycorrhizae forming fungi in plant roots is also manipulated in the course of this work.



THE HARVESTING OF HEMLOCK

in accordance with the group-selection method of natural reproduction. Instead of being even-aged the stand is composed of groups of trees of different ages. As the oldest groups reach maturity they are cut, and the opening is seeded by the surrounding trees. By this partial cutting system the ground is partly shaded at all times, the young trees are afforded protection, restocking of the openings is assured, fire hazard is kept low, and products may be periodically harvested.

for an organized allocation of funds will be made, as needed, to assist individuals associated with the Harvard Forest, the Arnold Arboretum, the Bussey Institution and the Biological Laboratory. Thus practically the entire income from the new Cabot Foundation can be utilized to support direct work on the problems involved without attendant overhead for land, buildings, laboratories, equipment, libraries or senior personnel, Harvard University being already well equipped in material resources essential to the initiation of investigations in this new field.

Dr. Cabot has long been impressed with the increasing importance of cellulose both as a substance and as a source of energy. Solar radiation is a primal source of energy, and in the living plant nature has provided us with a marvelous mechanism for storing that energy. Obviously, there are fixed limits to the earth's land area suitable to plant growth, and there is a limit to the number of plants that can be grown per acre. The possible answer to the problem of an increased production of cellulose seems to lie in the development of faster growing plants, either because of inherent genetic qualities of individual forms or species or because of improved soils. An investigation of these two lines of attack, particularly in reference to forestry, is now made possible through this recent gift.

The project is an exceedingly complex one, inevitably associated with the many years that constitute a tree generation. It is, however, reasonable to suppose that over a considerable period of time results can be obtained in tree-breeding as striking as those obtained in the breeding of food plants. We thus embark on a single line of investigation that may take several generations of research workers to complete, and we may have confidence that Harvard University has the stability and tenacity of purpose to carry this program through to a distant and successful conclusion.

As at present organized, the Cabot



THE OLDEST CULTIVATED STAND ON
THE HARVARD FOREST

twenty-nine years of age, which dates back to the first logging operation conducted under the university's ownership, in 1908. It has received four silvicultural treatments, in the form of weedings and thinnings, which have resulted in a high-quality mixture of trees of valuable species. Through the elimination of the weed trees and the reduction of competition the very best individuals in the stand have been favored from the start, and these are now five to seven inches in diameter and over fifty feet in height.

Foundation will have no staff of its own corresponding to the staffs of the eight units associated under the administrator of botanical collections of Harvard University. It will be supervised by an administrative committee, made up of members of the staffs of the units mentioned above, including also members of the Biological Laboratory group. It is planned to develop the involved research program in coordination with existing units of the university and in cooperation with other private and governmental agencies that are interested in this general field.

Investigations have already been commenced under the supervision of Professor K. Y. Thimann on methods of vegeta-

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tive propagation of promising strains, particularly the conifers. Professors E. M. East and Karl Sax have initiated a study of the hybridization of trees by artificial pollination, in order to evolve more rapidly growing strains. They will also attempt to induce the doubling of chromosome numbers in selected forms with the objective of increasing the size, vigor and hardness of woody plants and with the added objective of possibly establishing hybrids that may be propagated by seed instead of by vegetative reproduction. Professor R. P. Gast will continue and amplify his program on the effect of controlled quantities of nutrients and solar radiation on the rate of growth of trees and will extend his investigations to the nutritional qualities of natural forest soils and their improvement; he will also supervise the

selection and propagation of the most promising natural strains of different tree species, which are known, in many cases, to vary widely, even within the same species.

The research program as at present developed is a tentative one, subject to modification, amplification and reorientation as the work develops. For this reason it has not been considered expedient to utilize any considerable amount of the income for salaries of permanent employees, but rather to so allocate the funds that, as desirable or expedient, lines of attack that prove to be unproductive may be discontinued, and investigations in other fields developed.

E. D. MERRILL,
*Administrator of
Botanical Collections*

HARVARD UNIVERSITY

THE COMETS OF 1937

THE six comets so far observed in 1937 do not constitute a record-breaking number, but the three rather bright ones have provided considerable interest and activity in the comet world. Finsler's Comet has been by far the most interesting because of its comparatively great brilliancy. In recent years there has been a dearth of bright comets. Peltier's Comet of 1936 at its maximum was nearly as bright as Finsler's, but unfortunately for both the professional and amateur astronomers the maximum brightness occurred nearly at full moon so that the comet was visible to the naked eye only under the best atmospheric conditions. Finsler's Comet was singularly well placed for good observation. Its nearest approach to the earth on the 9th of August coincided so closely with its perihelion passage on August 15 that it remained for several days at an optimum brightness of about fourth magnitude, easily seen but not conspicuous to the naked eye. The moon reached first quarter on the 13th, so that observations were not hampered by any background skylight arising from a bright moon. In addition, the comet's apparent path lay

close to the north celestial pole and passed through the handle of the Great Dipper, making the comet a circumpolar object for most of the observers in the northern hemisphere.

Although Finsler's Comet did not approach the sun closely, its perihelion distance being about 80 million miles, it possessed a tail more than two million miles long, near the time of its greatest brightness. This tail was pointed almost directly away from the sun and was of the long, narrow and nearly straight type. In addition to this principal tail, very conspicuous photographically or with field glasses, there developed in early August a second tail, roughly two hundred thousand miles in length, that was directed about 40° away from the principal tail. This second tail was little more than an elongation of the corona, but was definite enough to deserve the name of a tail. Multiplicity of tails is not an abnormal phenomenon in comets. For example, the Comet of 1744 exhibited twelve tails at one time and the Morehouse Comet in 1908 possessed five tails that rapidly changed in form. The complex processes of ejection of material

*Photograph by L. E. Cunningham*

COMET FINSLER

from a comet's nucleus and the apparently erratic action of radiation pressure produced by sunlight on this material provide ample reason for diversity of form in the head and tail of a comet.

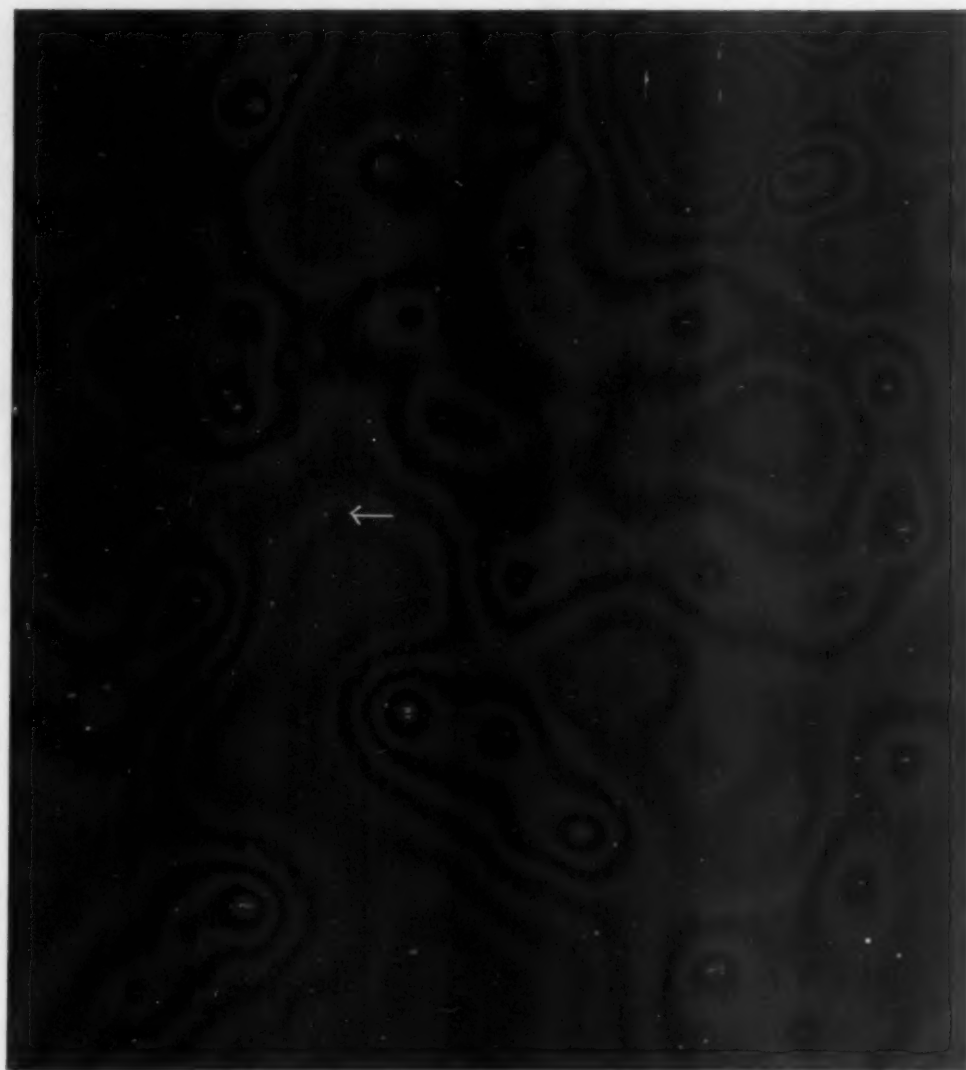
At the time of writing no reports have been made concerning any results of spectrographic observations on Finsler's Comet. Technique in spectrographic photography of faint diffuse objects has so far progressed in recent years that one should expect a considerable advance in the knowledge of cometary processes

from observations of this well-placed bright-comet.

Professor Paul Finsler at Zurich, Switzerland, made his discovery on July 4. Preliminary orbit calculation by Mr. Leland E. Cunningham at Harvard University and Dr. Allan D. Maxwell, of the University of Michigan, showed that the comet, which was then of the seventh magnitude, would probably attain naked eye brilliancy. The retrograde motion indicated that the period was probably long and that the parabolic assumption

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COMET WHIPPLE

ARROW POINTS TO THE COMET

would almost certainly represent the motion for a considerable interval of time. To date the deviations from parabolic motion have been too small for the determination of the true eccentricity of the orbit. There is little doubt that the period of revolution is of the order of hundreds of years.

The comet of 1937 second in brilliancy to Finsler's was discovered by Dr. A. Wilk at Cracow, Poland, on February 27. It was then of the seventh magnitude just below the threshold of naked

eye visibility but quickly faded away because of its rapid recession from both the earth and the sun. Its perihelion distance was slightly under 60 million miles.

The comet third in brilliancy was discovered by the author in February. Although very well placed for observation and intrinsically quite bright, this comet had such a great perihelion distance, 150 million miles, that it attained a maximum brightness of only about eighth magnitude, too faint to be seen by the unaided eye.

It is interesting that all three of these new comets possess very great periods of revolution about the sun, so that none of them will be observed at a second opposition. The fourth new comet of the year was discovered by Dr. Edwin P. Hubble at the Mount Wilson Observatory on August 4. It is of the thirteenth magnitude but may increase considerably in brightness if the preliminary orbits are correct. Its slow apparent motion and its position near opposition to the sun make the results of the orbit-calculation very sensitive to small errors of observation. Apparently the inclination of the orbital plane to that of the earth's revolution is small, so that there is a good possibility that Hubble's Comet may have a short-period orbit. At the present time the comet is in the constellation of Aquarius, rather far south for good observation at very northern ob-

servatories, and its path will probably lie close to the ecliptic at all times, unless there is a close approach to the earth.

Two periodic comets were rediscovered this year. Mr. S. Simiyu at Simada, Japan, found the Daniel Comet in early February. This rediscovery was important because the comet had not been observed at the three oppositions succeeding its discovery in 1909.

The periodic comet, Grigg-Skjellerup, was rediscovered by Cunningham at Harvard on April 30, making the fifth apparition at which this comet has been observed since its original discovery in 1902. Its period of five years is the smallest known except for that of the Encke Comet. Although it was not seen at the oppositions of 1907, 1912 and 1917 it has been observed regularly since then.

FRED L. WHIPPLE

HARVARD OBSERVATORY

THE EXPLORATION OF THE UPPER AIR BY THE UNITED STATES WEATHER BUREAU

A NEW system of upper-air exploration, to begin on September 1 at Burbank, Calif., and on September 15 at Fairbanks, Alaska, has been announced by Dr. W. R. Gregg, chief of the Weather Bureau. For several months, radiometeorographs—robot weather observers that broadcast their findings from far above the earth to human observers on the ground—will be released daily with balloons at these two stations.

Those at Fairbanks will pick up first news of cold waves bound for the United States from the North Pole. Those at Burbank will provide upper-air weather news for forecasters all over the country. At the end of the trial period, the bureau hopes to substitute these balloon-borne radiometeorographs for aerometeorographs attached to airplanes that now make routine upper-air soundings at a number of stations from coast to coast.

The performance of the new radio instrument will be carefully checked. At Fairbanks an aerometeorograph will be taken up on a plane about every third day. Results at Burbank will be com-

pared with those obtained by the Navy's aerometeorograph sent up daily at San Diego.

The radiometeorograph promises to remove one of the greatest handicaps to weather forecasting the world over—the dearth of up-to-the-minute information on conditions in the upper air on which to base forecasts. Self-recording meteorographs attached to balloons or to airplanes—now used for the purpose—have serious limitations, according to Gregg. Airplanes may fail in bad weather—usually the time when upper-air observations would be most valuable. Seldom do they rise more than three miles. Sounding balloons—gas bags five feet in diameter—go far up into the stratosphere, but usually they do not drop their recording instruments where observers will find them immediately. Every minute counts in getting out the weather forecasts at the six regular forecast centers and special forecasts for fliers at some fifty airport weather stations.

The new robot weather observer—the

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result of extensive research here and abroad—reports by wireless the temperature, pressure and humidity of the air through which it passes. The bureau expects also to develop radio direction-finding apparatus which will indicate how hard the wind is blowing, and from what direction, at each altitude. The observers get all this information almost instantaneously. So far as the record goes, they are not concerned with the instrument's drop back to earth after the balloon bursts at an average height of ten miles. A small parachute between the radiometeorograph and the hydrogen-filled balloon, which has a diameter of sixty inches, makes this drop as safe as possible. Some radiometeorographs will be damaged, possibly beyond repair, before they are recovered, and some may never be found. The loss of a few is not serious, however.

The instrument consists essentially of a miniature wireless set which broadcasts the responses made by three elements sensitive to atmospheric changes. Attached to each element—one responsive to pressure changes, one to temperature changes and one to humidity changes—is a tiny hand or lever, which moves as the element moves. A fourth small hand, kept in motion by a special clockwork, passes over the three other hands, making contacts as it goes. At each contact a signal is broadcast. A receiving set at a ground station picks it up. Trained observers translate the time intervals between the contacts caused by changing atmospheric conditions and the regular contacts of the moving arm with fixed points into pressure, humidity and temperature readings.

A radio direction finder set up above the receiving set provides information on the direction and velocity of the wind aloft. Radio waves from the moving

transmitter in the sky, striking the antennae of the direction finder, permit the observer to determine the height and position of the instrument. From a chart of these positions several times each minute the observers compute wind velocity and direction at various altitudes far into the stratosphere.

The radiometeorograph observations from Burbank and Fairbanks, going out by radio and teletype, will reach forecast centers and airports almost as soon as they are taken.

For accurate translation of the radiometeorograph's signals into temperature, pressure and humidity readings, observers must know how the instrument responds to atmospheric changes. This is determined by a preliminary checking—"calibration"—of each instrument before it is released. The Weather Bureau will calibrate the instruments going to Alaska; the manufacturer, those used in California.

The Weather Bureau has a new cabinet for calibrating its robot observers—a pressure-temperature chamber with the most modern devices for regulating air conditions within. Pressure, temperature and humidity in the cabinet are made to correspond with those the radiometeorograph might be expected to meet as it rises through the atmosphere. The time intervals between its signals from the cabinet are noted. They provide the basis for evaluating the records obtained on regular ascensions.

The radiometeorographs will be delivered to the Weather Bureau in small lots, so that the manufacturers can immediately incorporate any new developments that will improve performance. Like the first automobile, present radiometeorograph models are open to the improvements and refinements which are bound to come.

P. N.

EXPLORING THE ATOM

DISINTEGRATION of the atom is expected to solve much of the mystery surrounding the structure of matter. It involves adventure in the unknown realms

of pure science and promises the rewards of important engineering achievement.

At the East Pittsburgh research headquarters of the Westinghouse Electric



ARCHITECT'S DRAWING OF PROJECTED "ATOM SMASHER"

and Manufacturing Company, there has now been completed plans for the world's largest unit for conducting experiments in the field of nuclear physics. The "atom-smasher," as it is popularly termed, consists of a huge pear-shaped tank, thirty feet in diameter and forty-seven feet long, housing an electrostatic direct current generator and other required parts, including a forty-foot vacuum tube. Air within the tank will be held to a pressure of 120 pounds per square inch. The entire structure will be about as tall as a six-story building.

Voltages generated in the "atom-smasher" will range to 5,000,000 and beyond. Such high voltage will accelerate

ions or particles of matter, shot through the vacuum tube at about a tenth of the speed of light. Then, leaping from the end of the vacuum tube through thin windows of metal, the particles will strike the targets of various metals, at velocities high enough to penetrate the nuclei of the atoms and thus produce nuclear reactions. The results of the bombardment will be counted, measured and identified by special instruments developed for this purpose.

Physicists continue to investigate new processes, energies and sequences of operations that provide nuclear reactions and transmutations of one element into another. By constant progressive steps

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of experimenting they may learn how to duplicate the changes that occur in nature, how to vary elements and how to create new products. Accelerated progress in this direction is expected to result from the data gathered as the Westinghouse "atom-smasher" is put to work.

Comparatively recent discoveries have started a scientific revolution which probably will have far-reaching results in discoveries that involve fundamental knowledge, and nearly all such knowledge gained has found practical application.

Though we do not know where our investigations in the field of nuclear physics will lead us or exactly what results we shall gain, we do know from the experience of pioneer investigations that in this field are hidden golden nuggets of scientific opportunity.

In direct charge of the work will be Dr. William H. Wells, who has contributed many new features to the design of the equipment.

L. W. CHUBB, *Director*

RESEARCH LABORATORIES,
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THE MEETING OF THE BRITISH ASSOCIATION AT NOTTINGHAM

CONTINUING the trend of the 1936 meetings toward the practical application of science, the British Association for the Advancement of Science will feature two group discussions along this line in the 1937 meetings during the first eight days of September. The Sections of Geography and Geology will unite in a consideration of the potential resources of the area surrounding Nottingham; these sections will join the Sections of Zoology, Botany, Agriculture and Economics in a program on planning of the land of Great Britain.

Nottingham is in the center of an industrial area, providing an admirable location for meetings of this nature. When not attending sessions, members will take excursions to observe the hosiery, chemical, mining, tobacco, bicycle and general engineering undertakings in the near vicinity.

Besides aiming toward practicality, the British Association conducts each year an informative program tending to popularize science. This consists of a series of public lectures in various outlying districts, parallel with the regular meetings. The 1937 program includes an address to the Nottingham children by Dr. Alexander Wood on "Noise"; to a Derby audience by Sir Gilbert Walker on "The Science of Sports"; at Lincoln by Mr. R. Kay Gresswell on "Rivers"; at Long Eaton by Dr. J. E. Constable on

"Everyday Applications of Physics"; at Mansfield by Professor J. Walton on "Coal and its Origin"; and at Newark by Mr. T. M. Herbert on "Transport of Food."

The presidential address to the entire group will be delivered in Albert Hall by Sir Edward Bagnall Poulton, who was Hope professor of zoology at Oxford from 1893 to 1933. His theme, the history of evolutionary thought as recorded in the meetings of the association, is especially appropriate for a group which maintains Darwin's home as a national memorial. Born in 1856 and educated at Jesus College, Oxford, Sir Edward has long been a student of Charles Darwin and of evolution. He was president of the Linnean Society from 1912 to 1916 and is honorary life president of the Royal Entomological Society.

Other evening meetings will be addressed by Professor J. Gray, who will discuss the movements of fish; Professor H. Hartridge on "Illusions of Color," and Dr. R. E. Slade on "Grass and the National Food Supply."

Sectional meetings will be held in the University College buildings in University Park. These buildings, which provide not only pleasant surroundings but an open-air swimming pool, were the gift of the late Lord Trent and were opened by His Majesty King George V in July, 1928.

Two functions are scheduled for social diversion. The lord mayor and members of the city council will hold a civic reception at Nottingham Castle on September 2, and the college council will entertain at a garden party on September 7.

The 1937 meeting is the third gather-

ing of the association in Nottingham, the second having been held in 1893 and the first in 1866. The records of the first meeting show that Wheatstone was president of the Section on Mathematics and Physics and that Joule read a short paper on the heating effect of an electric current in a wire. C. P. K.

THE FORTHCOMING ROCHESTER MEETINGS OF THE AMERICAN CHEMICAL SOCIETY

THE ninety-fourth meeting of the American Chemical Society convenes in Rochester during the second week of September, under the general chairmanship of M. H. Eisenhart, president of the Bausch and Lomb Optical Company. The honorary chairman is Florus R. Baxter, who until his retirement was director of the research laboratories of the Vacuum Oil Company.

Seventeen professional divisions of the society and the microchemical section have scheduled sessions. On September 8, the society as a whole convenes in the Eastman Theater for a general program to be addressed by three prominent scientific men. Dr. E. R. Weidlein, director of the Mellon Institute of Industrial Research, Pittsburgh, will deliver the annual presidential address of the Society on Tuesday evening.

At twenty-three symposia, special reports of developments affecting industry, nutrition, public health, pure science and education will be presented. Artificial radioactivity and its chemical uses, studies of the chemistry of the earth's crust, low temperature methods and research, chemical microscopy, quantitative spectroscopic analysis and photography will be among the session topics of the division of physical and inorganic chemistry. The National Research Council's insulation committee will join with the division in a symposium on the chemistry and physics of electrical insulation.

Medicinal patents, vitamins and the chemistry and metabolism of fats will be considered by the divisions of agricul-

tural and food, medicinal and biological chemistry. The cellulose division will emphasize research on cellulose derivatives, while the paint and varnish division will feature organic plastics. The industrial and engineering chemistry division will hold half-day symposia on "unit processes" and "automatic control."

The characteristic properties and chemical utilization of hydrocarbons will be the chief subjects of the petroleum division. Two days will be devoted by the gas and fuel division to "Gaseous Combustion," during which will be covered the kinetics of ignition, flame propagation, inflammation limits, internal combustion engines, problems in fuel rating and the state of the burned gas.

A wide variety of papers will be heard at other divisional sessions, including investigations dealing with sugar, rubber, water, sewage and sanitation, microchemistry, organic chemistry, fertilizers and colloids. A symposium and informal colloquium on chemical engineering education will be sponsored by the chemical education division. The division of the history of chemistry will celebrate its founding sixteen years ago in Rochester.

All-day trips to the Corning Glass Works, the Taylor Wine Company and the Pleasant Valley Wine Company have been arranged. Industrial laboratories in Rochester, including those of the Eastman Kodak Company and of the Bausch and Lomb Optical Company, will be visited. A. C. S.

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